TECHNOLOGY DEPT.

Power Generation and POWER PLANT ENGINEERING

For ALL Power Engineers • Steam, Electricity and All Other Power Engineering Services

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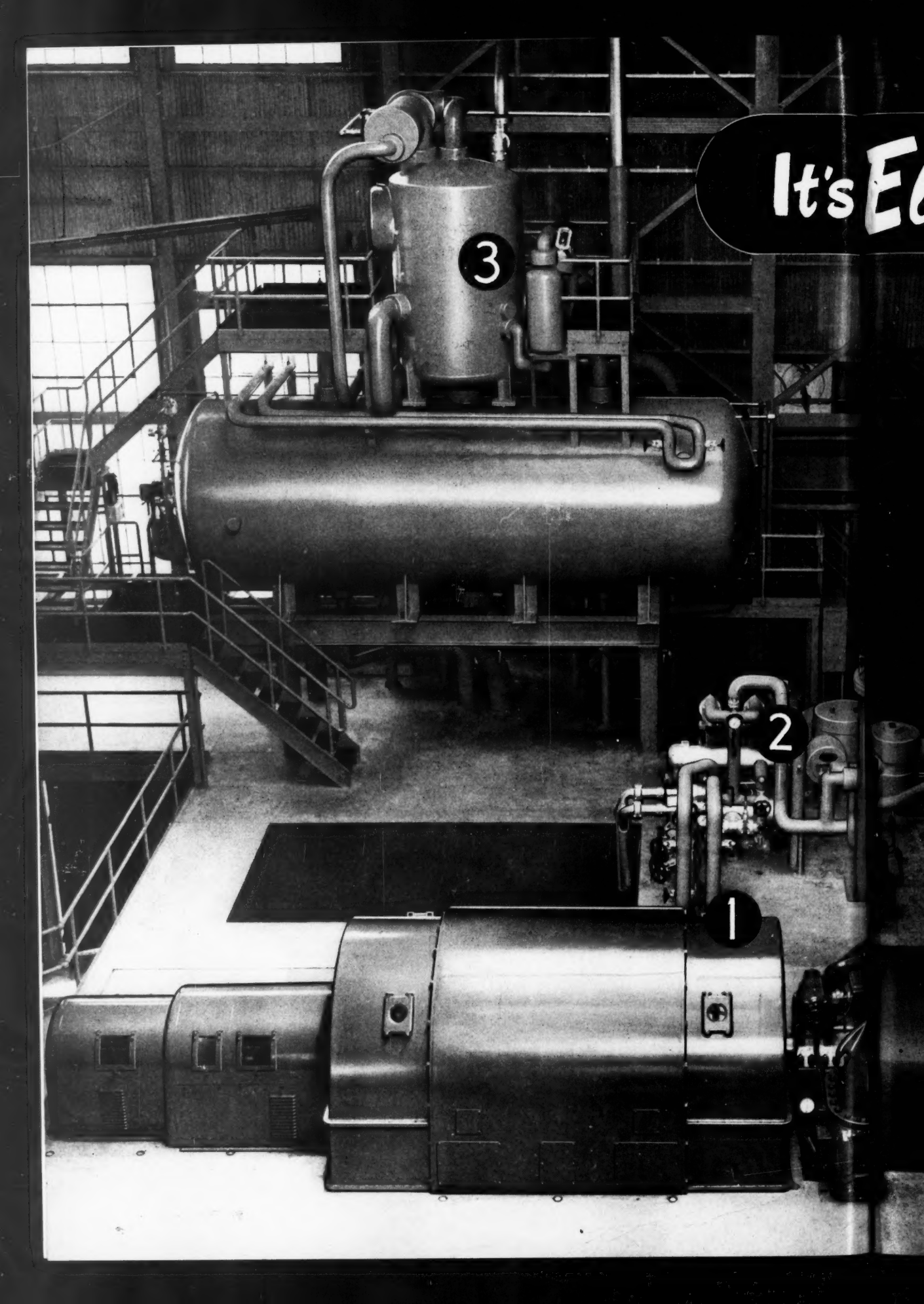
100 In. Hg

Basic Power Plant Figuring—More on Pressure Reducing

NOVEMBER 1949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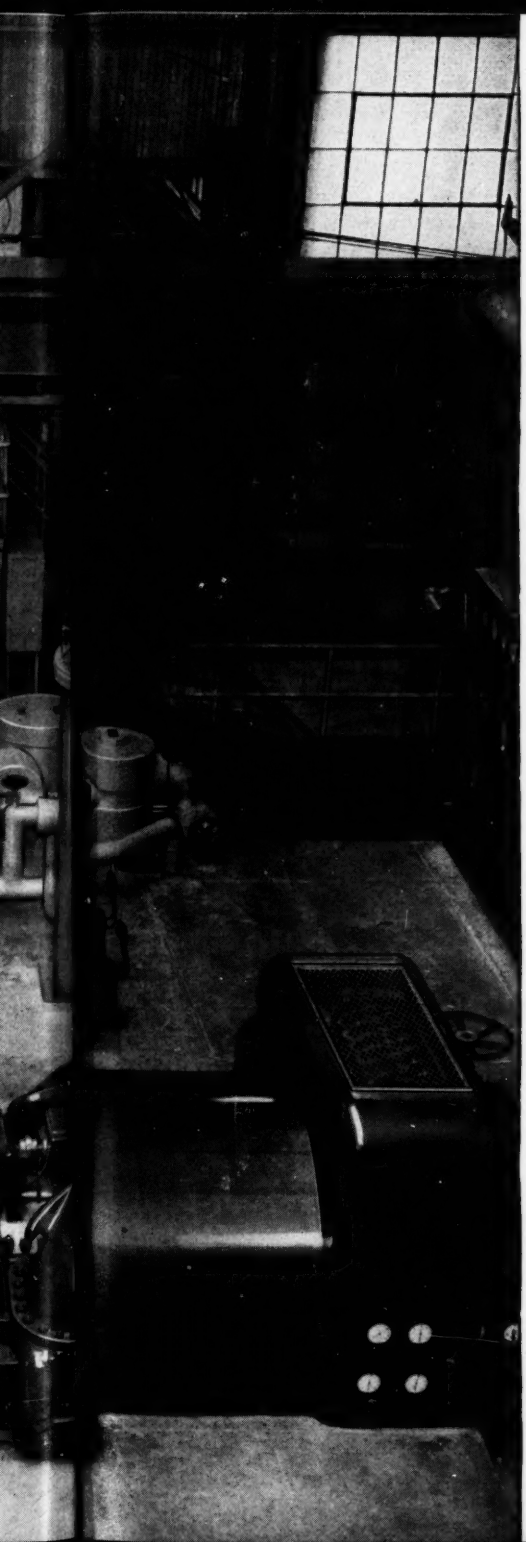

1 In the foreground, an Elliott turbine-generator unit — clean-lined, businesslike, and all-Elliott throughout . . .

2 Just back of the turbine-generator, an Elliott twin two-stage steam jet ejector which serves the Elliott surface condenser under the main turbine . . .

3 In the background, the Elliott vertical deaerating feedwater heater mounted on its horizontal storage tank, unsleeping sentinel against corrosive elements in the boiler feedwater . . .

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Power Generation

November 1949

VOLUME 53—NUMBER 11

Notes on This Issue

Twin Branch

For many years power people have kept an eye on Twin Branch Station of the American Gas & Electric Service Corporation. A part of the far flung A. G. & E. System it was the first station to use 2000 lb steam pressure.

Unit No. 5 has now been added to Twin Branch. It combines for the first time in a single unit the highest steam pressure (2000 psi), the highest steam temperature (1050 F.), and the highest capacity; and will operate with a heat rate of better than 9200 Btu. per kwh. This is a record breaking achievement.

Written by leaders in the field this description of the new unit and the thinking which created it is of tremendous interest to the entire engineering world.

Mechanical Voltage Regulators

These regulators are, of course, indispensable in operation of a-c generators and the operator needs to know how to adjust and maintain them.

Vibrating type regulators have given good service and many are in use but new voltage regulators are of the direct-acting mechanical type and are simpler in construction.

The article includes pictorial diagrams which explain how the devices are used in practice.

Diesel Fuel

This short, well illustrated article is of particular interest to owners and operators of small plants and designers.

It describes how three 1000 hp. Diesel engine-driven generators supply the city of Plattsburgh, N. Y. at extremely low power costs. Over a five year period power production has been at a rate of over 14 kwh. per gallon of fuel oil.

Why the Compressed Air Was Wet

Compressed air must be delivered dry or much damage may result. One of the causes of inaccuracy and actual damage to instruments and control equipment is moist air.

This is a case story of the problem in a granite-cutting plant, how they located the oil and water leak.

Homopolar Generator

This article describes the new, improved homopolar generator at the Carnegie Institute of Technology. The homopolar generator has intrigued electrical engineers and designers for many years. In fact, Faraday's original electrodynamic machine was homopolar.

The outstanding advantage of this generator is that it is the only type capable of producing an absolutely unvarying direct current, but it has had many shortcomings which prevented its general use. Many of the difficulties have been overcome in this new machine at Carnegie Tech.

Engineers interested in low d-c potentials will find the details extremely valuable.

Spreader Stoker

For the past ten years manufacturers have been so busy making and installing spreader stokers that they have not taken time to correlate all the information about them. This year the stoker manufacturers set up a project to do that job and results are now becoming available.

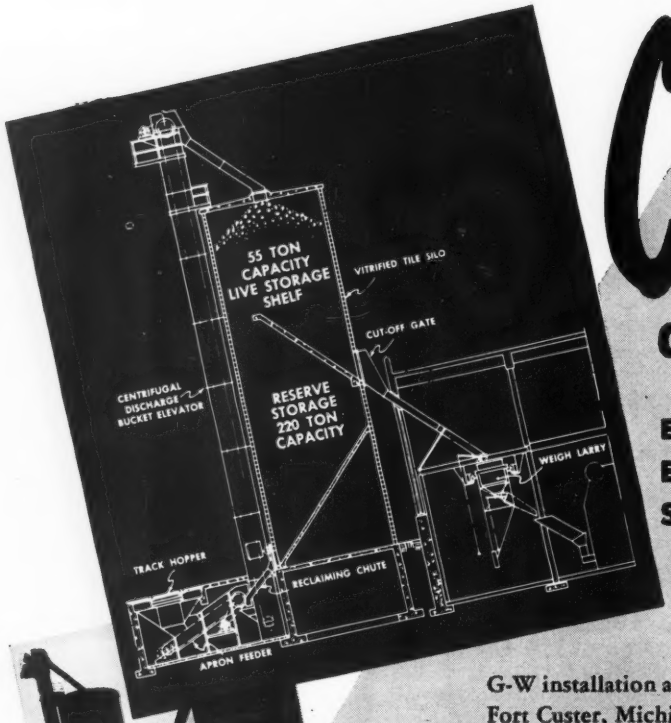
As you know spreader stokers have been used for 40 years but principally in the locomotive field. They entered the stationary field in a large way just before the war. They have advantages in range of coals and offer economies in boiler sizes up to 200,000 lb of steam per hr.

Mr. Fred D. Mosher has had a wealth of experience in the boiler field. He has written articles for POWER GENERATION. This is the first of three articles on the recent stoker studies written specifically for power plant engineers.

Boiler Feed Pumps

Mr. I. J. Karassik is one of our most popular authors. In his position as Application Engineer for many years he has learned a great deal about all kinds of pumps.

This article takes up the frequently discussed problem of adjusting condensate returns to boilers to permit constant speed in the boiler feed pumps. The information given is extremely important to power plant engineers, designers and manufacturers of boiler equipment. It goes into transfer tanks, condensate transfer pumps and various control devices in the piping.



Check YOUR coal handling costs

EXCESSIVE EXPENSE COULD EASILY PAY FOR THIS G-W SYSTEM IN A SHORT TIME

Obsolete equipment and methods can easily absorb, in *excessive handling costs,* the outlay required for this modern G-W installation at the Veterans Administration Hospital, Fort Custer, Michigan.

Here, G-W engineers designed this Vitrified Tile Silo and handling equipment as the most efficient system *for maintaining coal handling costs at a minimum.* One of G-W's *four basic designs,* it incorporates a reclaiming system which utilizes the entire capacity of the silo as live storage. G-W Vitrified Tile Silos are low in first cost, can be quickly erected, and are durable and architecturally harmonious.

G-W Vitrified Tile Silo Storage System at Veterans Administration Hospital, Fort Custer, Mich. Capacity, 25 tons/Hr. Silo: 18′0″ Diam., 55′0″ high. Storage Capacity: 275 tons, with 55-ton live storage shelf and 220-ton reclaimable live storage. G-W 1500-lb. Weigh Larry with recording beam.

135 years of experience have taught G-W engineers that, although no two coal handling problems are exactly alike, practically all of them boil down to *4 basic designs* for storage and handling.

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No matter how different or difficult your coal (and/or ash) handling problem may be, from one of *4-basic types . . . Concrete Silos, Vitrified Tile Silos, Cylindrical Steel Tank,* and *Suspended Steel Bunker* . . . G-W engineers can install the most efficient and economical storage and automatic handling system to fit your conditions of space, capacity and allowable initial cost.

Fourteen interesting case histories, based on these *4 G-W basic designs,* are described in Bulletin No. 300. Write for your copy, today.

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ENGINEERS' PREVIEW

AN ALUMINUM PISTOL? Absurd! Everyone knows a hand gun has to be machined from solid steel—steel of the best quality—steel that is usually forged before machining. A semi-automatic pistol takes a lot of abuse. The slide or the breech block slams to the rear at about 45 miles per hour. In the 0.45 caliber automatic pistol, the head of the cartridge case exerts a rearward thrust of almost a ton. It takes a pretty rugged piece of machinery to absorb such punishment for thousands of rounds.

Yet early in 1948, according to the *American Rifleman*, the Colt Co., working towards the development of a more universal acceptance of lightweight, heavy caliber, automatic pistols, decided to see what would happen if a receiver was made from aluminum rather than from the standard alloy steel forging. Working with the Aluminum Corporation of America, it was decided after experimentation to try one of the high tensile strength aluminum alloys. Several forgings of this light metal were specially made and the final result was a half dozen 0.45 caliber automatic pistol receivers.

These were assembled into pistols for various sizes of cartridges. The new slide was fashioned from forged steel as before, but shortened from 7⅜ in. to 6⅞ in. in length, and the barrel was correspondingly cut down from 5 in. to 4¼ in. This made possible an overall length of 5⅞ in. compared to the previous 8½ in. Other changes in detail were made and the new lightweight gun with magazine weighed in at about 26½ ounces as compared with the all steel gun weight of about 40 ounces.

The new lightweight weapons shoot as well as the originals, according to those who have tried them. However, keep in mind that they have as yet made only a half dozen of these lightweight automatic pistols.

★ ★ ★

CERAMIC bodies previously developed by the National Bureau of Standards have marked superiority, in both strength and creep characteristics at 1800 F and above, over the best available high-temperature metal alloys. Laboratory data indicate that these ceramic bodies, especially designed for use in jet engines and gas turbines, possess special properties required at the elevated operating temperature of these power plants.

★ ★ ★

SIX STRETCHES of street pavement in New York City are being laid containing a new "meltable rubber" compound, in a cooperative test by the Office of Manhattan Borough President and United States Rubber Co. The rubber compound, known as Surfa-Sealz, was blended with the asphalt commonly used in making black-top pavement. The rubber-asphalt pavement is expected to resist cracking in winter and softening in summer.

★ ★ ★

DURABLE flame-retardant chemical for cotton and rayon, which does not change the appearance or feel of those materials, has been announced by the Du Pont Co. The treatment is durable to dry-cleaning, normal home laundering, and weathering. Properly applied, the chemical has no effect on the draping qualities, appearance, "feel" or strength of the materials.

NEW AND SIMPLER process for welding boiler tubes, which effects a large saving in time, has been developed at the Chattanooga, Tenn., plant of Combustion Engineering-Superheater, Inc. The new method not only provides these advantages of simplicity and time saving but also makes possible a consistently high quality of weld.

In many large modern boilers continuous tubes of lengths in excess of 100 ft are required, and to make them it is necessary to join two or more commercial lengths of tubing. The principles of induction heating and pressure welding are both employed in the new process which is used to make tube joints. A high frequency generator supplies power for the induction coil, the heating from which serves in effecting a pressure-type weld. A feature of the new apparatus is an enclosed atmosphere to protect the welding surfaces against oxidation during the heating period. Both straight and bent tubing may be welded by this method.

★ ★ ★

FOR THE PAST ten months the ASME Boiler Code Committee has found it necessary to recommend a number of changes and additions to the various sections of the Code. These include: (1) Revision of the Preamble of the Low-Pressure Heating Boiler Code in order to more clearly define the capacity limits of hot water supply boilers; (2) Revision of the classification of welding operators; (3) Amplification of stress tables P-7 and U-2 to assign allowable working stresses to SA-213 materials in Grades T7 and T9; (4) Revised formulas for bolted flanged connections; (5) Provisions for construction of unfired steam boilers in both the power boiler and unfired pressure vessel codes; (6) Adoption of working stresses for use with copper, nickel, and aluminum materials and their alloys; (7) Revisions of thirty-six existing material specifications and inclusion of six new specifications.

Prices for the 1949 Addenda to:	
Power Boiler Code	$0.50 ea.
Material Specifications	1.25 ea.
Locomotive Boiler Code	0.10 ea.
Low-Pressure Heating Boiler Code	0.15 ea.
Miniature Boiler Code	0.10 ea.
Unfired Pressure Vessel Code	0.50 ea.
Welding Qualifications	0.10 ea.

The 1949 Edition of the Boiler Construction Code is scheduled for publication in November. In its pages will be incorporated the addenda published during 1947 and 1948, as well as those issued in September of 1949. For further details and prices on complete code, write to ASME.

★ ★ ★

WE THOUGHT we had seen and heard almost everything, but now they spring on us—air conditioned outdoor movie theaters. These, according to Heating and Ventilating, can now be provided with cooled, dehumidified and filtered air for summer comfort and heated and filtered air for winter comfort. This is done by distributing the air through an insulated, underground pipe system installed under the entire parking area. At each parking station there is installed at the base of the speaker post a small coil and blower unit similar to the ordinary automobile heater, except for a difference in capacity. A flexible tube connected to this coil and blower unit discharges the conditioned air into the automobile.

BETTER TOOLING for white-collar workers is paying handsome dividends at C. F. Braun & Co. located in Alhambra, California. "Better tooling" consists of a private, air-conditioned, well-lighted, oak-paneled office for nearly every designer or draftsman, accountant, secretary, stenographer and clerk. These well-equipped private offices are provided for employees because it is economical. Experience has proved that in a private office production increases, morale improves, losses and time waste (incident to dirt, noise and interruptions) are either lowered or eliminated. So says *American Business 7-49* in an article by Eugene Whitmore.

Average salary of the men occupying these offices is $360 a month. Production increased 35 per cent when the men went into private offices. It is estimated that time savings alone—because of fewer interruptions, less distraction, and because the offices are cleaner and there is less spoilage—amount to 25 per cent. This figure means a saving of $90 a month to the company. Is it good business to invest $3,500 instead of $2,000 if the additional investment of $1,500 creates a saving of $90 a month?

C. F. Braun says: "The time-worn argument against privacy is that certain groups of people work pretty closely together—use the same files and such. Therefore, they must be in the same room. The people who repeat this lore forget that each of our private offices has a door with ball-bearing hinges. Then there's another bit of hardy lore. If mental workers are watched like so many schoolboys, it alleges they'll put out. But who could ever watch a man think? . . . Perhaps a mental worker can be watched into looking busy, but he will put out only according to his interest.

"There is yet another time-worn defense of the 'bull pen.' A private office may be right for a mental worker, tradition grudingly admits. But, continues tradition, a draftsman is not a mental worker—a private office for him is rank extravagance. Nonsense, we say. The work of a draftsman, accountant, or the like, is probably 90 per cent mental . . . We must keep in mind that the lines, the words and figures we put on paper are nothing but symbols for expressing our thoughts. The thoughts are what we want for our money."

★ ★ ★

WHY CERTAIN substances "jell" may be learned from study of synthetic chemicals in Kodak Research Laboratories, Kodak scientists said at the fall meeting of the American Chemical Society. Two types of experimental substances called synthetic polymers were described. One type has to do with gelatin, another with cellulose.

Gelatin is widely used in photographic film. It is the material which, when combined with silver salts, forms the light-sensitive photo emulsion. Gelatin, however, is a complex substance. Its structure has not yet been completely explained.

This is where the value of polyacrylamide comes in, the scientists point out. The synthetic material is far less complex in structure than the natural gelatin.

Research on another type of synthetic materials, known as ester lactones, was also reported by Minsk, Waugh and Kenyon at the meeting.

These ester lactones are of scientific interest because they contribute indirectly to the study of cellulose. They have a chemical structure, which, in one particular respect, appears to be akin to that of cellulose. The physical properties of their sheets are somewhat like those of cellulose esters.

A COST CONSCIOUS London bank has installed a television circuit between its city offices and a record storage building in a small country town. Executives in the main office can see records quickly by television. Storage space in the country costs 35 cents per square foot instead of $8.00 in the city.—*The Ohmite News*

★ ★ ★

NINTH General Conference on Weights and Measures, held in October 1948, adopted the name "Celsius" for the scale of temperature that has more commonly been called "Centigrade". This action, which had not been proposed in advance of the Conference, arose from a question regarding preferred usage in French, the sole official language of the Conference. The decision therefore may be considered as applying strictly only to that language. In the interest of eventual uniformity of practice the use of Celsius appears desirable, but it is not practicable to impose the term on those who prefer Centigrade.

In preparation for the General Conference, the National Bureau of Standards submitted a revised text defining the International Temperature Scale to supersede that adopted in 1927. The proposed text was drafted in English, and, in accordance with common English practices as well as the official French text adopted in 1927, it used the name Centigrade. This name was carried over into the French translation prepared for consideration by the Advisory Committee on Thermometry in May 1948. However, in the printed report of that meeting, the term Centigrade had, in most cases, been changed to Centésimale, the term that is used in the French Law governing weights and measures. When asked to choose between the two, the International Committee on Weights and Measures and the General conference voted to substitute Celsius.

Celsius (abbreviated C) is analogous to the names Kelvin, Fahrenheit, Reaumur, and Rankine used for other temperature scales, that it has previously been used considerably in some countries, and occasionally in America, being included in Webster's dictionary. It might also be argued that Centigrade is logically ambiguous, since the absolute Kelvin scale, as well as the Centigrade scale, has 100 degrees between the ice point and the boiling point of water. On the other hand, the name Centigrade is thoroughly established in English-speaking countries, the need for choosing between that name and Centésimale arises only in French, and the decision on a term in the official French language of the Conference may not be considered as controlling the terms to be used in translation into other tongues.

★ ★ ★

NERVE-WRACKING decibels are being eliminated by Illinois Institute of Technology scientists who put the noisy engines into a padded cell and study what parts are responsible. Wilson P. Green, professor of mechanical engineering at IIT, has designed a double-walled engine noise test room in which he can make accurate sound measurements. It is built on a 4-inch platform of soft rubber and lined with a 6-inch thickness of fireproof fiberglass and is believed to be the only such room in existence. "We measure the loudest part first, usually the exhaust, reduce it, and then go on to the next loudest," Green explained. "Every gear, piston, and moving part is carefully checked and muffled." Green maintains that any engine, automotive, locomotive or power plant can have at least 50 per cent of its noise muffled by proper diagnosis and design without altering the power or efficiency.

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YOUR BOILER WATER LEVEL?

Dependable, constant indication of boiler water and other liquid levels is now available with a complete Yarway system.

At the boiler drum—Yarway offers the well-known Hi-Lo Alarm Water Column with tubular or pressure-sealed Flat Glass gages with "floating assembly" that reduces leakage and glass breakage.

On the instrument panel—Yarway's Remote Liquid Level Indicator, operated by the boiler water itself, gives instant, accurate indication at eye level. Or the Yarway HI-LO-GRAPH Recorder gives both indication and round-the-clock recording of the water level.

Throughout the plant—at any desired locations, Yarway Remote Signal Alarms (lights or horns) operated by a Control Unit on the Yarway Indicator, or Recorder, give additional checks on boiler water levels.

Why not let a Yarway Engineer show you how this Yarway System can increase the efficiency and safety of your power plant operation?

For complete information on Yarway Indicators ask for Bulletin WG-1822.

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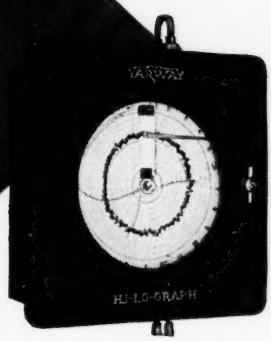
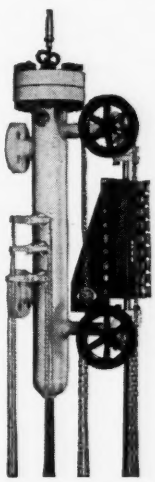


Yarway HI-LO-GRAPH Recorder provides not only water level indication but a 24-hour recording of water levels. See Bulletin WG-1830.

Yarway Remote Hi-Lo-Alarm Signals—Lights or Horns. Can be placed at any location in plant.



Yarway Floatless Hi-Lo Alarm Water Column with Vertical Flat Glass Gages with "Floating Assembly." See Bulletin WG-1811

Acceptance the Real Test of a successful development

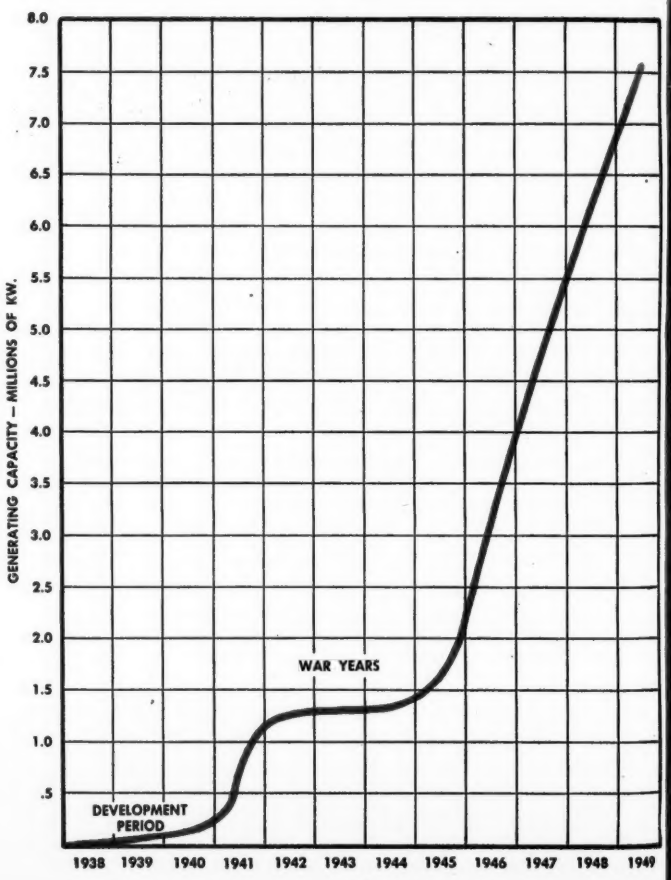
The enthusiastic acceptance by the electric utility companies of the Vertically-adjustable Burner—major adjunct to Combustion's long established tangential method of firing—is graphically expressed on the accompanying chart. It tells the story more clearly perhaps than mere words can.

Introduced initially in 1938, this burner—it's more than a burner, it's a method of firing—went through a brief development period, was successfully applied in several plants, and then ran into war restrictions which precluded utility station expansion. Nevertheless, the die was cast, and when a tremendous postwar utility expansion program got under way in 1945, the Vertically-adjustable, Tangential Burner—the Tilting Burner, if you will—zoomed to immediate success.

Since the war's end electric utilities have installed or ordered C-E pulverized coal fired units with an aggregate capacity in excess of **64,000,000 lb** of steam per hr, **88%** of which is equipped with Vertically-adjustable, Tangential Burners . . . well over **1,000,000 KW** a year is the postwar average capacity of the units equipped with "Tilting Burners."

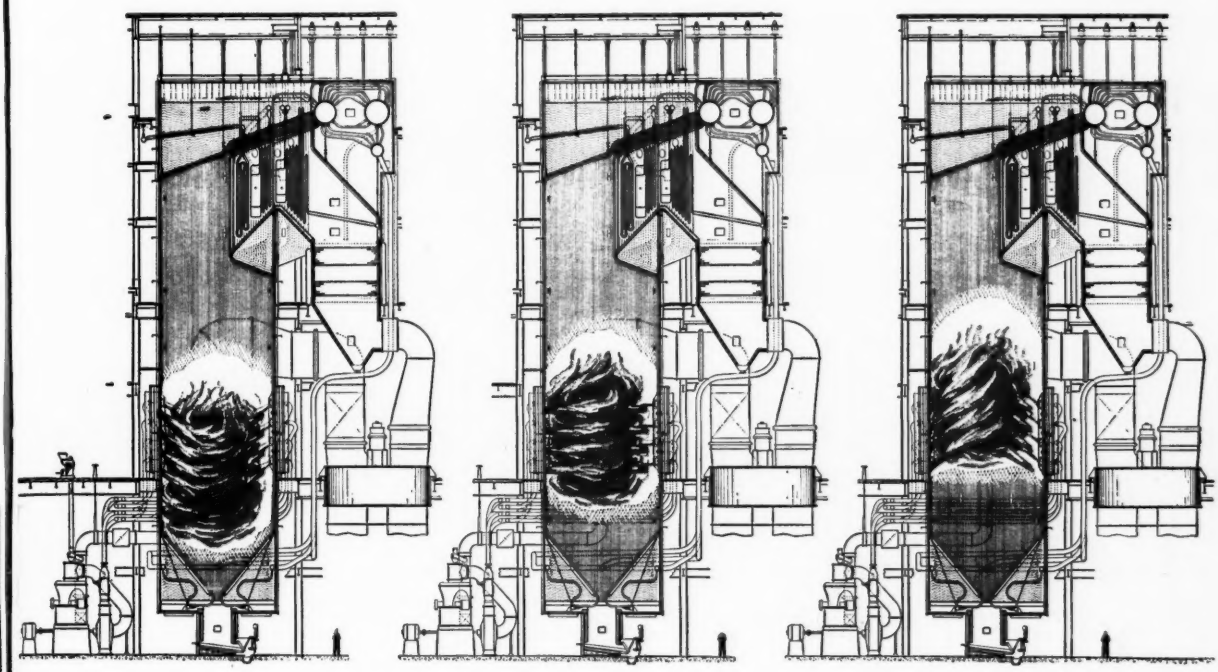
No other burner—no modern method of firing pulverized coal—can point to any such record of buyer acceptance.

The diagrammatic representation of the "Tilting Burner" and resumé of its principal advantages, given on the opposite page, will assist in understanding the reasons for its success. B-345



COMBUSTION ENGINEERING

A MERGER OF COMBUSTION ENGINEERING COMPANY, INC. AND THE SUPERHEATER COMPANY



Advantages of the Tilting Burner

The combination of tangential firing and the Vertically-adjustable Burner accomplishes certain highly important results beyond the reach of any other burner or firing method presently available. These are:

1. Control of the temperature of furnace gases at the furnace exit which permits:

(a) Control of superheat temperatures over a wide range.

(b) Minimum use of desuperheating spray.

(c) Use of wide variety of coals.

(d) Accurate proportioning of superheater and reheater surfaces.

(e) Lower air heater maintenance.

2. Substantial control over slagging conditions which results in:

(a) More uniform furnace conditions.

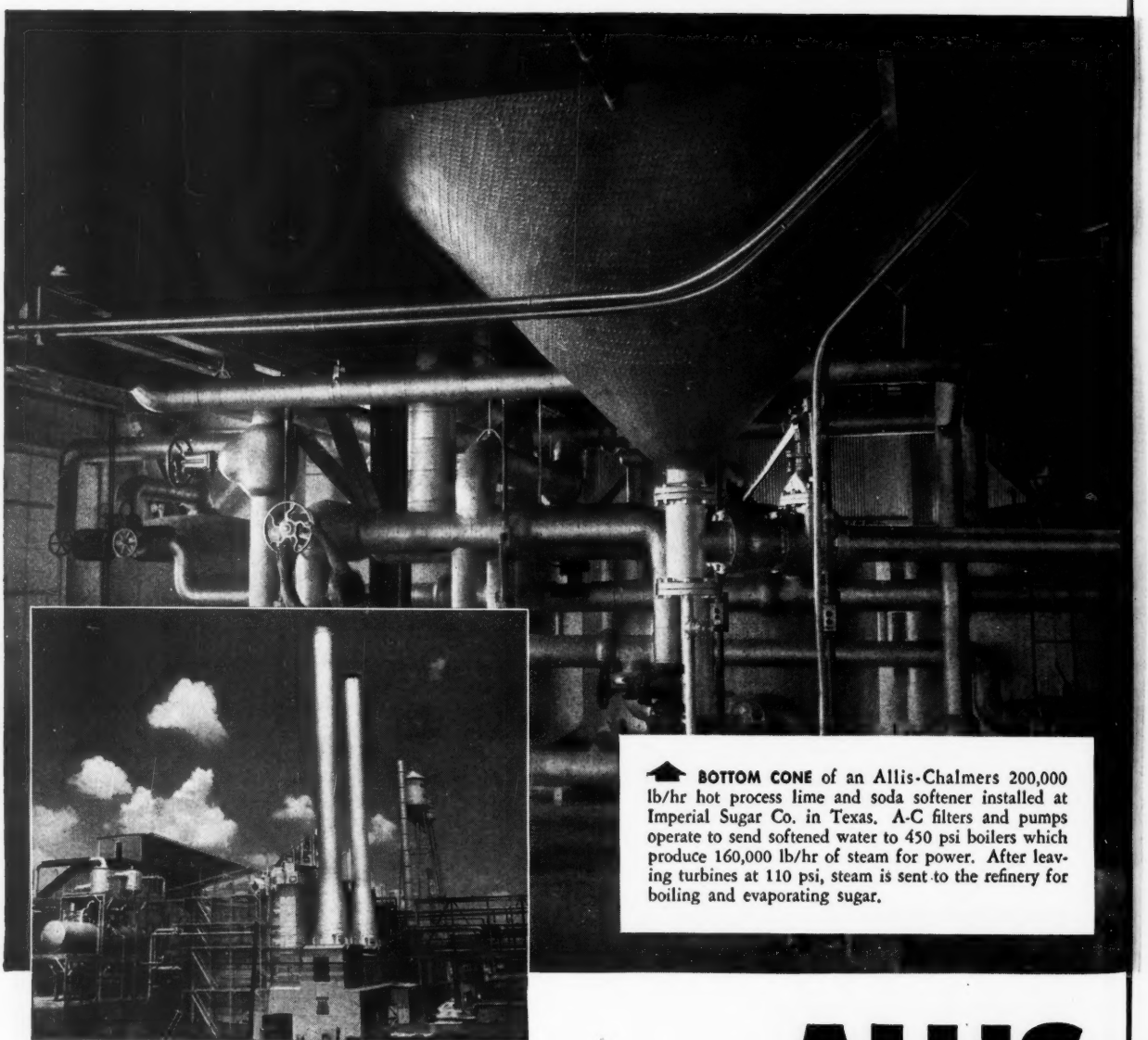
(b) Better heat absorption.

(c) Minimum use of soot blowers.

— SUPERHEATER, INC.
200 MADISON AVENUE NEW YORK 16, N. Y.

ONE OF A SERIES • • • *Allis-Chalmers Water Conditioning* SERVICE

3-way program water treatment



BOTTOM CONE of an Allis-Chalmers 200,000 lb/hr hot process lime and soda softener installed at Imperial Sugar Co. in Texas. A-C filters and pumps operate to send softened water to 450 psi boilers which produce 160,000 lb/hr of steam for power. After leaving turbines at 110 psi, steam is sent to the refinery for boiling and evaporating sugar.

CLEAN STEAM for sugar processing leaves the new power plant for the Southwest's leading sugar refinery, helping to produce 1,600,000 lb of refined sugar per day.

ALLIS-
Water Conditioning

ing SERVICE • CHEMICALS • EQUIPMENT) *at Work in Industry*

helps you solve problems!

WHAT ALLIS-CHALMERS *SERVICE-CHEMICALS-EQUIPMENT* DOES FOR THESE FOOD PLANTS—IT CAN DO FOR ANY INDUSTRY THAT NEEDS COMPETENT TIME AND MONEY SAVING AID!

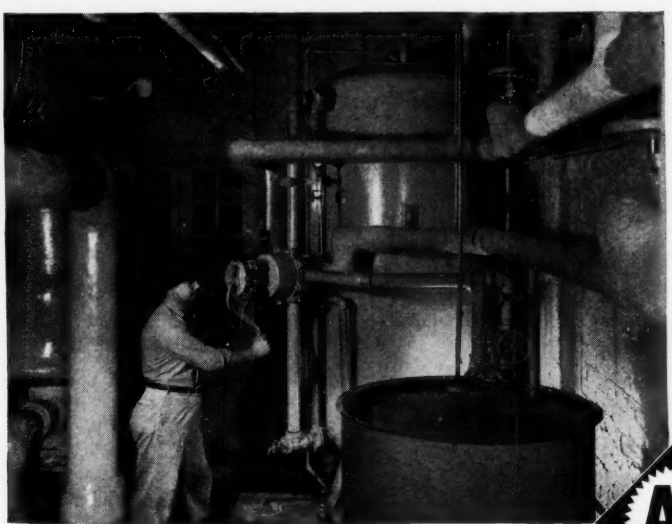
PLANT MEN IN FOOD-PRODUCING industries like sugar refining and dairying, for example, know the need for action when water treating problems arise. They know, too, that to work with a competent water conditioning organization means a savings in time and effort for all concerned.

For *all* industries, Allis-Chalmers in the water conditioning field not only provides a first hand study of water treating needs, but works right along with customer engineers in selecting the right process and correct equipment.

ALLIS-CHALMERS SERVICE starts with a complete study of water supplies and impurities, surveys of present methods and plant operating conditions. Following this: recommendations, selection of chemicals, periodic reports, and service calls.

CHEMICALS comprise a complete new line of formulations for scale and corrosion control in all types of cooling towers and heat exchangers. Also reliable AKON and SILIMITE which effectively prevent boiler scale and corrosion . . . reduce silica.

EQUIPMENT includes hot and cold process softeners, sodium and hydrogen zeolite softeners, degasifiers, deionizers, chemical proportioners, and oil removal and water filters.



SODIUM ZEOLITE softener at Pabst Farms Dairy in Wisconsin is a 9,000 gal unit treating extremely hard well water for steam-pasteurizing and evaporating fresh milk.

Akon and *Silimite* are Allis-Chalmers trademarks

A-C ALLIS-CHALMERS

CHALMERS

Service . . . Chemicals . . . Equipment

ALLIS-CHALMERS, 953A SO. 70 ST.
MILWAUKEE, WIS.

Please send me:

- ☐ 6385A Chemicals and Equipment, Analysis Instructions and Price List
- ☐ 6611 Description of Hot Process Water Softeners
- ☐ 7107 Sodium Zeolite Softeners

Name.....

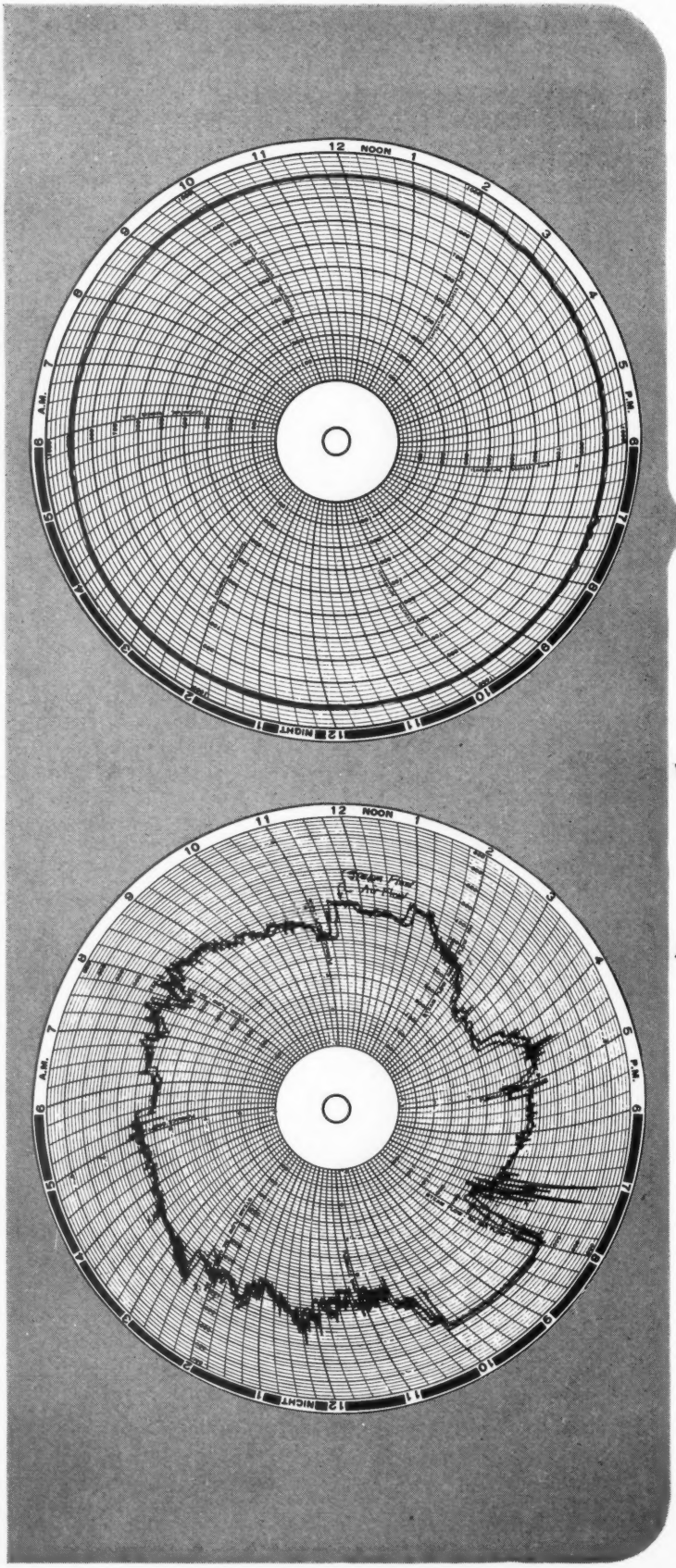
Company.....

Title.....

City.....

State.....

A 2639



Precision Co

MAINTAINED WI

Typical steam-temperature chart from a large central station boiler equipped with B&W Spray Atemperators shows uniformity of final superheat temperature.

Steam-flow chart shows wide load variations on the same boiler throughout the corresponding period of operation.

SERVICE-PROVED ON OVER 100

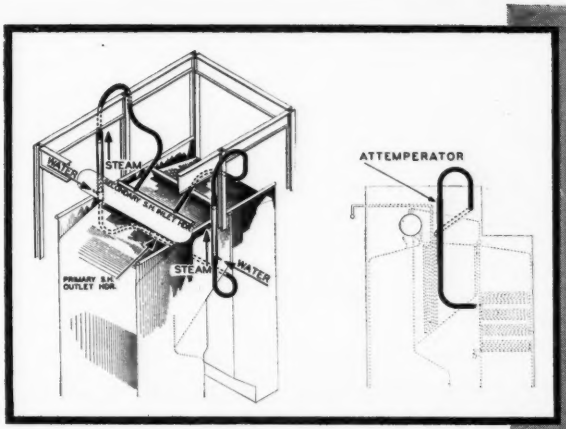


Fig. 1: Intermediate location of attemperator reduces alloy requirements . . . overcomes unbalanced temperature conditions in second stage superheater.

n Control of Superheat

ED WITH B&W SPRAY ATTEMPERATORS

For many high-temperature boiler installations, B&W Intermediate Spray Attemperation provides the most effective means of superheat control, and often at demonstrably lower cost than other types. Located between primary and secondary superheaters, Spray Attemperators offer the obvious economy of reduced alloy-tube requirements by maintaining uniform tube temperatures in the second stage, where temperatures are highest (see Fig. 1). Harmful impingement of spray water on pressure-piping surfaces is effectively prevented by a special venturi liner, which also assures rapid evaporation of the spray water and dry steam to the second stage superheater (see Fig. 2).

These facts help explain why so many power companies prefer B&W Spray Attemperation. Have your B&W representative explain fully its advantages for safe, efficient high-temperature operation.

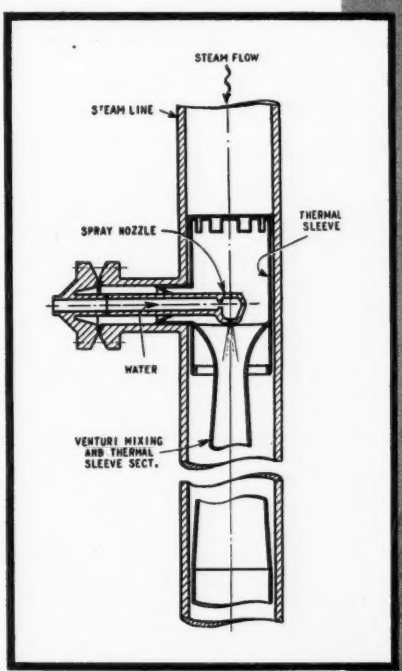


Fig. 2: Special venturi-shaped liner mixes atomized spray with steam, away from direct contact with pressure piping surfaces.

B&W

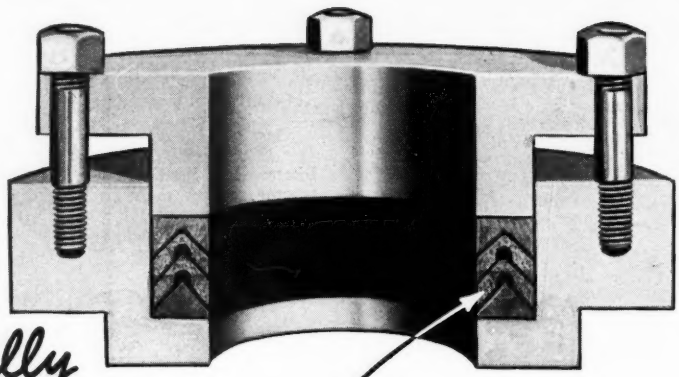
BABCOCK & WILCOX

100 BOILERS SERVING OVER 5½ MILLION KW. OF GENERATING CAPACITY

G-457

QUESTION:

Which Garlock rod packing automatically adjusts itself to changing pressures?



NOTE EXCLUSIVE HINGE-LIKE CONSTRUCTION

ANSWER:

CHEVRON*

*Reg. U.S. Pat. Off.

GARLOCK 430
CHEVRON Packing

GARLOCK CHEVRON Packing is truly an automatic packing. The distinctive and exclusive hinge-like shape of CHEVRON packing makes it extremely sensitive to pressure changes. On the power stroke or with increasing pressures CHEVRON rings automatically tighten and prevent leakage; on the return stroke or with diminishing pressures the packing eases off, permitting free operation of the rod and reducing friction to a minimum.

For long life and dependable service, specify CHEVRON packing. GARLOCK 430 CHEVRON for hydraulic service; 431 for oils at low temperatures; 530 for steam, air or gas; 531 for hot oils.

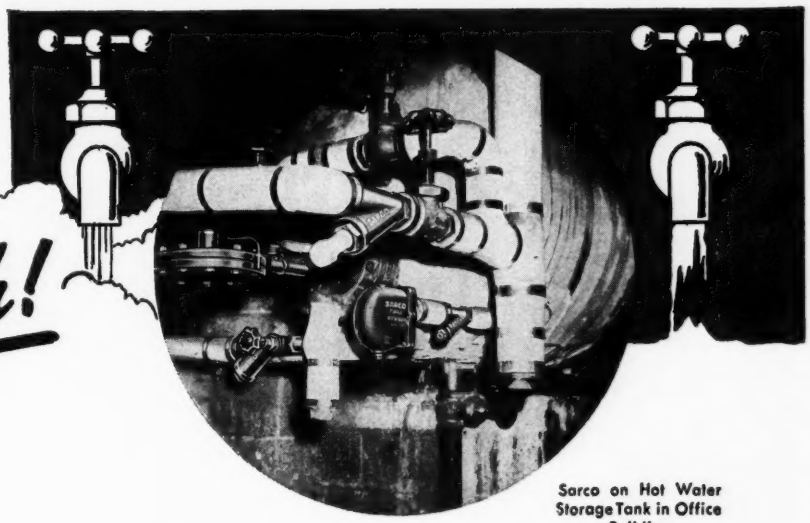
THE GARLOCK PACKING COMPANY
PALMYRA, NEW YORK

In Canada: The Garlock Packing Company of Canada Ltd., Montreal, Que.

GARLOCK

PACKINGS, GASKETS AND OIL SEALS

HOT WATER COSTS— *too Much!*



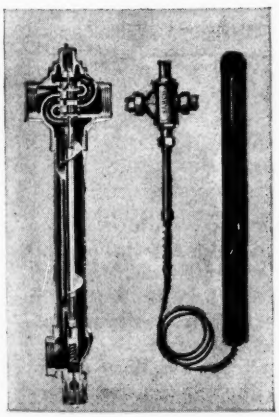
Sarco on Hot Water Storage Tank in Office Building

Sarco Blender in Apartment

WHEN IT IS TOO HOT OR TOO COLD

Hot water is a critical service, in buildings, in homes, or in industry. Poor service can be "explained" for a time. But when tenants get scalded, or workers "wait for it to warm up" because the water is too cold, things begin to happen that cost you money every day.

The strange thing is that the proper applications of Sarco Steam Traps, Temperature Controls and Water Blenders not only eliminate complaints, but result in lower fuel and water costs.



TANKS

If you have a storage tank—any one of several Sarco Trap-Control combinations will insure constant tank temperatures. Sarco never over heats—therefore it saves fuel. The Sarco 2430 Control shown above is one method.

APARTMENT

The phone rang all day and the boss wanted to install an additional tank. We put in a Sarco Blender at a cost of less than a dollar per apartment — now no complaints and much less water is wasted waiting "for it to get right."

INDUSTRIAL APPLICATION

The Sarco Water Blender is doing a good job in industry too. It insures exact temperatures at the point of use. In foods, it saves raw materials and rejected batches by having the water just right at the cooker or mixer. It is used for recirculating brine and cooling water in engines and compressors, and is the standard for wash rooms and gang showers. Bulletin No. 800.

254

SARCO SAVES STEAM

IMPROVES PRODUCT QUALITY AND OUTPUT

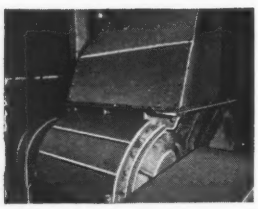
SARCO COMPANY, INC.

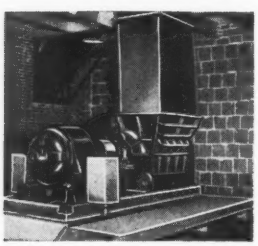
Represented in Principal Cities

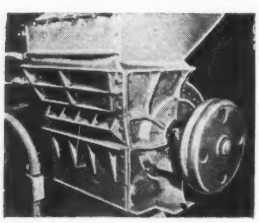
Empire State Building, New York 1, N. Y.

SARCO CANADA, LTD., TORONTO 5, ONTARIO

YOUR FIRST STEP toward GREATER COMBUSTION EFFICIENCY . . .



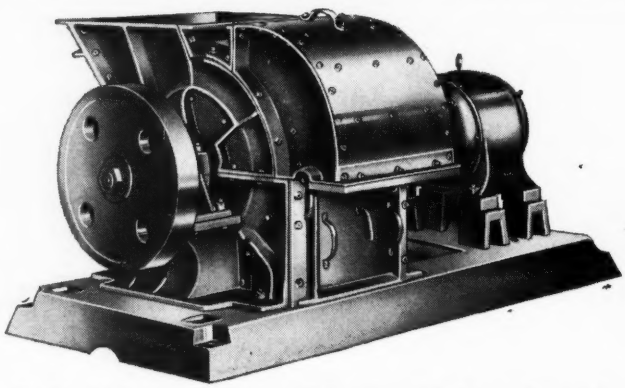




Custom-built for power plants, American Type "S" Crushers offer 9 different sizes, with capacities from 25 to 500 TP H.

AMERICAN *Rolling Ring* CRUSHERS

Uniform *High* Tonnage Reduction . . . at *Low* Operating Cost!



COAL IS SPLIT - NOT CRUSHED

American Type "S" Rolling Ring Crusher, with heavy cast steel housing and sectional construction, secured at dust-tight, machined joints with coupling bolts for easy access to crushing chamber.

To hit highest operating efficiency, coal firing depends upon uniform sizing . . . one reason it pays to include American Crushers in your expansion and change-over plans. The exclusive shredder ring action of Americans—*through splitting instead of crushing coal*—gives a dependable uniform product with controlled fines—assure a loose, uniform firebed quickly responsive to sudden steam demands . . . without excessive ashpit drop or unnecessary CO_2.
The minimum headroom requirements and independence from auxiliary crushing permit easy, economical installation of American without extensive alterations. Heavy cast steel housing and manganese steel shredder rings assure long, trouble-free service.

Send for your copy of "Crushing Coal for Less than 1¢ per ton."

American PULVERIZER COMPANY

Originators and Manufacturers of Ring Crushers and Pulverizers

1429 MACKLIND AVE.
ST. LOUIS 10, MO.

How to get a "SWEET" CONTROL JOB

There's More to Boiler Controls Than Regulators

If you want a sweet running control for your boiler plant—look to more than bare regulators when you write your specifications. Here are some additional points to consider:

Insist on controllable equipment

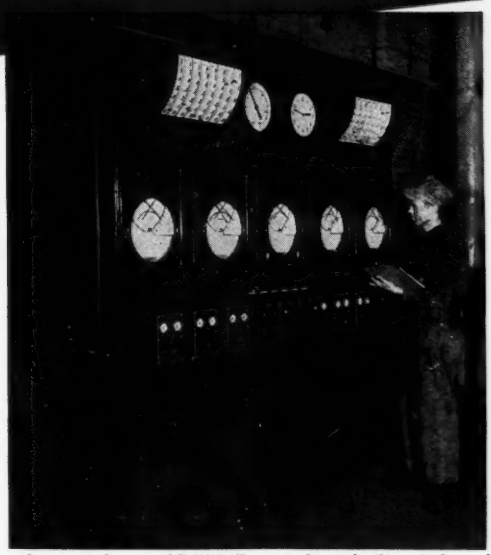
Fans, dampers, pulverizers, stokers, burners, and other equipment must be adaptable to automatic control before any system can give truly satisfactory results.

Control from all important variables

Multiple element control systems which respond to all of the important variables, insure against costly disturbances in plant operation. They increase safety, decrease auxiliary power required, and reduce the storage capacity needed in heaters and boiler drums.

Profit from the experience of others

Steam plants similar to yours already are being operated at optimum performance by Bailey Boiler Control. Your dividends, from our experience in making thousands of boiler control installations, take the form of refinements in control application which insure trouble free operation. Over 8,000 boiler units have been equipped with Bailey Controls during the past ten years. These units range from 3,000 to 1,000,000 pounds per hour capacity and operate at pressures from 75 to 2,500 psi. They are fired by pulverized coal, stokers, oil, gas, mixed fuels and waste fuels.



Control of two 65,000 lb. per hour boilers is based on the accurate measurements of these Bailey Meters at The White Motor Co., Cleveland, Ohio. Day to day evaporation runs consistently above the guarantee.

Operate control from accurate measurements

A control system is no better than the measurements to which it responds. Bailey Controls are based on accurate measurements made by Bailey Meters.

Consult Qualified Application Engineers

Bailey Engineers are qualified by training and experience to consult with you on both the theoretical and practical aspects of your boiler control problems. These specialists are conveniently located in over 30 industrial areas throughout the United States and Canada.

Details for Your Problems

If you want details write for a copy of Bulletin 15-D or ask a Bailey Engineer to call.

BAILEY METER COMPANY

1040 IVANHOE ROAD • • • CLEVELAND 10, OHIO

Controls for Steam Plants

COMBUSTION • PRESSURE
FEED WATER • LIQUID LEVEL
TEMPERATURE • FEED PUMPS

A-98-1

. . . PIONEERS IN

pd now present the V

Fig. 3—VALMONT TYPE S Tubular Dust Collectors are made from standard, mass produced "building block" units of 25, 20 and 15 tubes each, sized for easy handling. All tubes are firmly welded in place at the factory, reducing the field erection costs by eliminating the need for field assembly of the tubes.

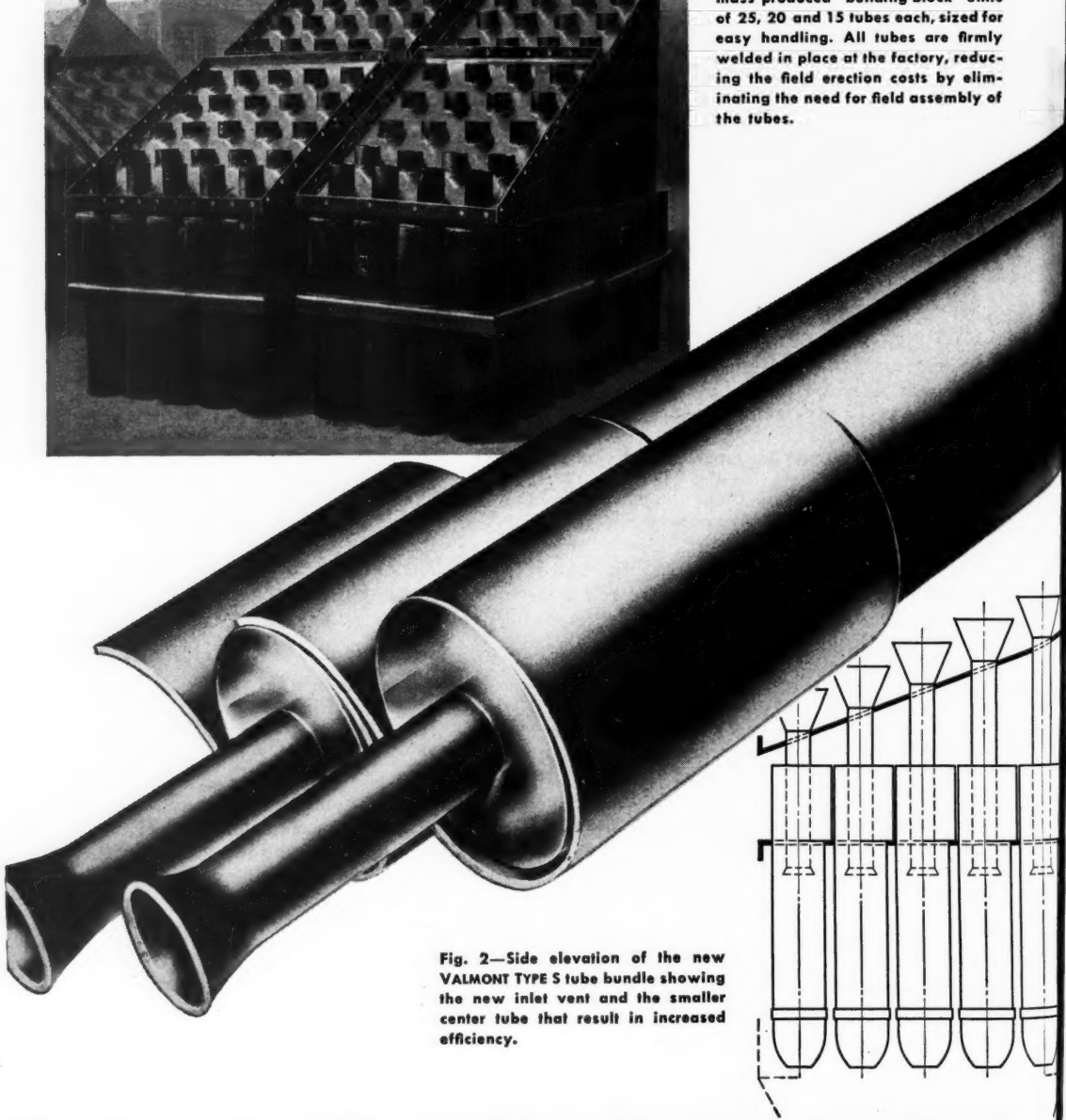


Fig. 2—Side elevation of the new VALMONT TYPE S tube bundle showing the new inlet vent and the smaller center tube that result in increased efficiency.

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PRAT-DANIEL C

DUST COLLECTION

VALMONT TYPE S

Fig. 1—The VALMONT TYPE S tube, heart of a new high in mechanical dust collection efficiency. Radical changes, inside and out, have placed this collector in a class by itself.

. . . UNEXCELLED BY ANY MECHANICAL DUST COLLECTOR

The VALMONT TYPE S Dust Collector is an entirely new design, based on an old principle. It employs the basic patented P-D feature of introducing the dust laden gas through a narrow, high inlet. This thin ribbon of gas reduces the distance of dust travel to the inner wall of the precipitating tube, thus increasing the ratio of collection on ultra-fine particles (in the critical range of from one to twenty microns).

The VALMONT TYPE S is new in many details of design that have been thoroughly tested and proven higher in efficiency . . . smaller in space requirements . . . lower in weight and cost. Such as the aerodynamic S shape of the gas inlet—the changes in proportion of width to height of inlet—the reduction in the size of the center gas outlet tube equipped with a flare.

In addition, to increasing efficiency, these design changes permit a much closer nesting of the tubes. Cost, weight and space are reduced accordingly—and the reduction in cubical requirements is particularly desirable when the collector is installed on existing equipment.

The VALMONT TYPE S is mass produced in building block units of 25, 20 and 15 tubes each, with all tubes welded in position at the factory. Field handling and erection costs are thus reduced and maximum efficiency assured.

Our project engineers, The Thermix Corporation, will be glad to plan the new VALMONT TYPE S into your new plant, or show you how easily it will fit into your existing layout. For additional information on this new advance in dust collecting write for Catalog No. 250S.

Project and Sales Engineers

(Offices in 28 principal cities)

THE THERMIX CORPORATION

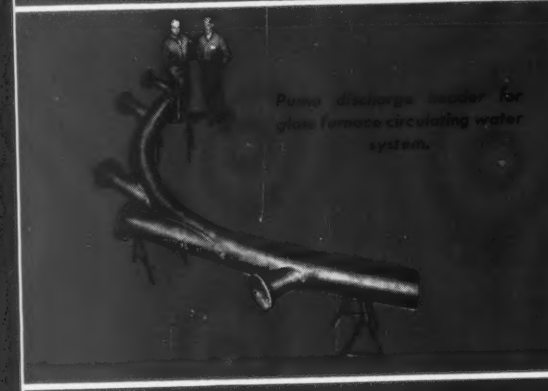
FIRST NATIONAL BANK BLDG. **GREENWICH, CONN.**

Canadian Representative: **T. C. CHOWN, LTD.**, 1440 Saint Catherine St., W., Montreal 25, Quebec

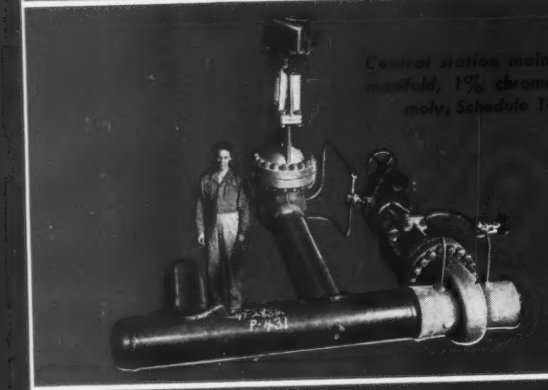
CORPORATION

EAST PORT CHESTER, CONN.

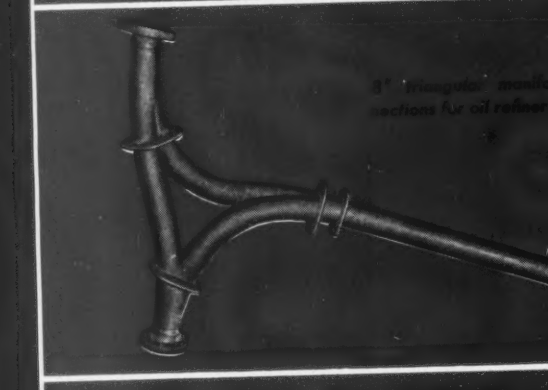
Section of 12" alloy steel all-welded main steamline for 900 psi working steam pressure.



Pump discharge header for glass furnace circulating water system.



Central station main steam manifold, 1¼ chrome, ½% moly, Schedule 100.



3" Triangular manifold connections for oil refinery piping.

Bleeder piping manifold for steam turbine fabricated from 24" and 20" pipe and Midwest Welding Fittings.

YOU SAVE Time and Money IN ERECTION by Using MIDWEST PREFABRICATED PIPING

Midwest Prefabricated Piping is precision piping . . . that is why it saves time and reduces the cost of field erection. Being contractors as well as fabricators, we know from long experience the importance of having the subassemblies accurate to dimension and alignment. Before shipment from any of the four modern Midwest shops, pieces are checked for dimensional accuracy and thoroughly cleaned to remove scale and dirt by turbinizing or acid pickling as may be specified. Careful inspection and pressure testing are other characteristics of Midwest Prefabricated Piping methods.

Another important reason for the ease of erection and economy of Midwest piping is the fact that the difficult operations are performed in the fabricating plant and field welding is simplified. Here again our extensive erection experience enables us to effect savings by locating field joints where they are easy to make.

You will find it to your advantage to use Piping by Midwest . . . it saves time, money and trouble.

MIDWEST PIPING & SUPPLY CO., Inc.

Main Office: 1450 South Second St., St. Louis 4, Mo.

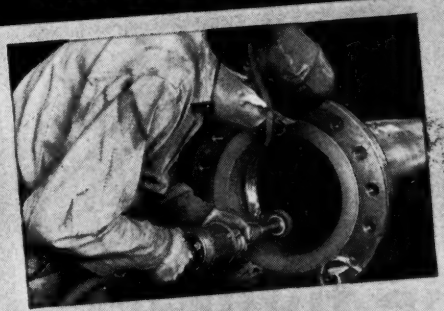
Plants: St. Louis, Passaic, Los Angeles and South Boston • Sales Offices: New York 7—30 Church St. • Chicago 3—79 W. Monroe St. • Los Angeles 33—520 Anderson St. • Houston 2—229 Shell Bldg. • Tulsa 3—533 Mayo Bldg. South Boston 27—426 First St.

4 PLANTS ARE BETTER THAN 1

CHECKING DIMENSIONS AND ALIGNMENT

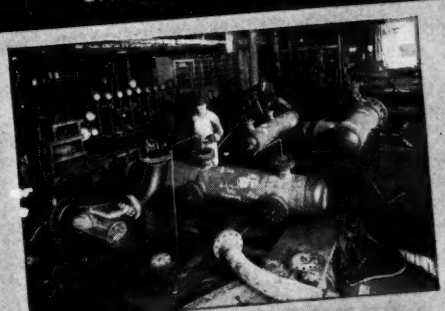
The careful check given every prefabricated subassembly before it leaves any Midwest shop saves time and trouble in field erection.

THOROUGH CLEANING

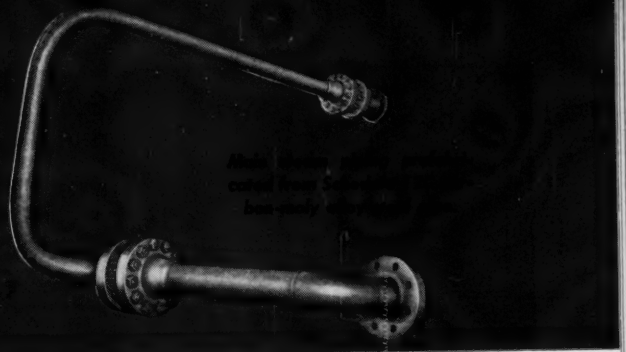


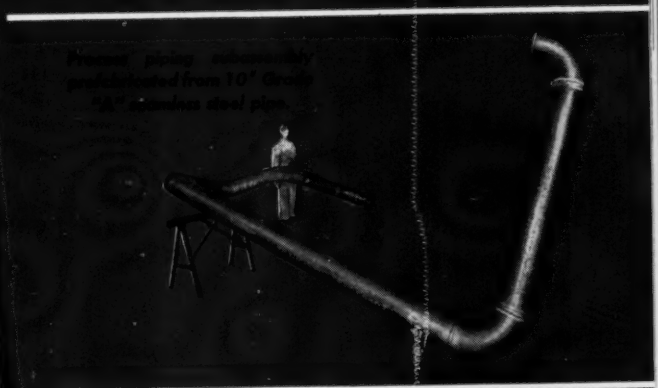
Prefabricated subassemblies are thoroughly cleaned before shipment from any Midwest plant and are turbinized when specified.

CAREFUL TESTING



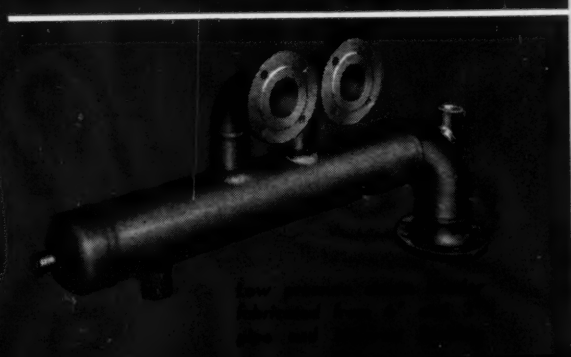
All Midwest plants have complete facilities for testing piping assemblies to assure their ability to withstand the most severe operating conditions.

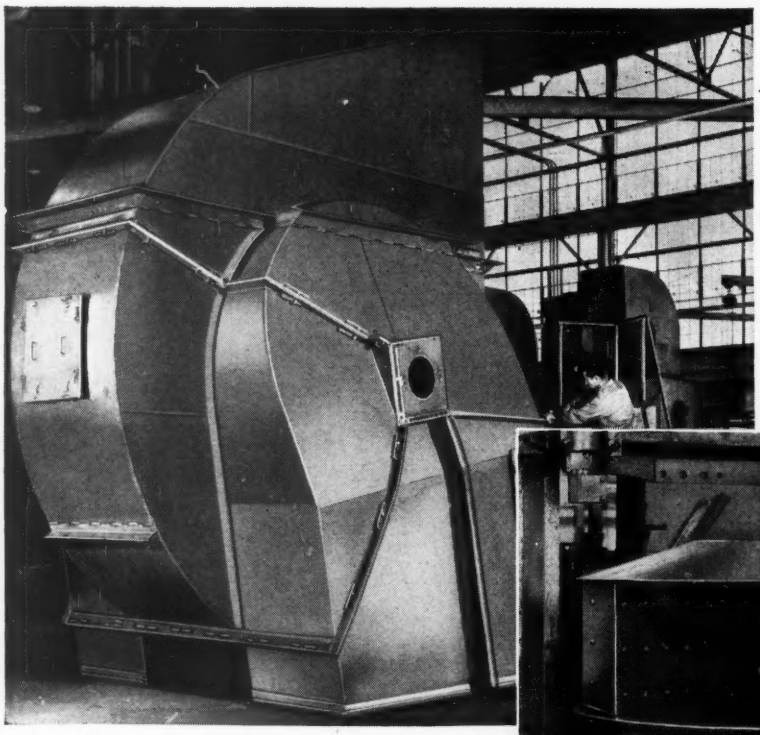




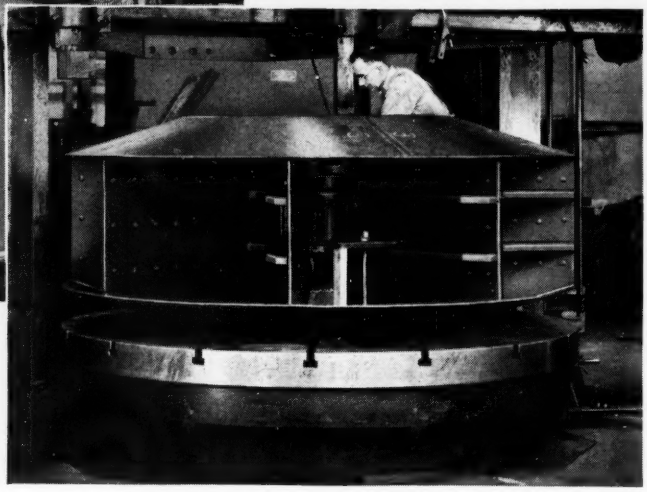
Pressure piping subassembly prefabricated from 10" Grade "A" seamless steel pipe.

Header for natural gas lines tested to 1400 psi.





American Blower Induced Draft Fan in early stages of construction. Photo shows fan in reverse elevation position with upper flanges representing foundation level. Rating, 170,000 cfm, 300° F, 26″ sp, 698 rpm, 978 bhp, 21,000 tip speed. Housing is of ⅜″ steel with all-welded construction and welded steel inlet boxes.



Boring mill operation—wheel is radial blade type—115″ diameter, weight, 7600 pounds. Shaft diameter is 13″ and includes 8″ water-cooled, self-aligning type bearings. Wheel has special spider design, is of extra-heavy construction and is provided with replaceable blade wearing pads.

Building for the future

Here, Bill Kociemba and Joe Waller, with years of experience on American Blower Air Handling Equipment, are building for the future.

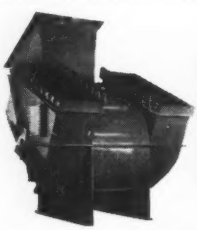
The object of their attention, in terms of the trade, is an American Blower Induced Draft Fan suitable for handling induced draft or hot gas exhaust.

These men, like all American Blower craftsmen, know by experience that there's only one way to build for the future. That way is to make each product so well that when another is ordered, American Blower will be specified.

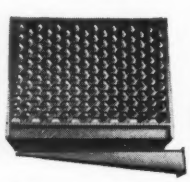
How about your plans for the future?

If they include modernizing, replacing obsolete equipment or plant expansion, it will pay you to call an American Blower Branch Office. Our engineers will gladly cooperate with you, without cost or obligation, on any problem involving air handling.

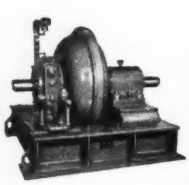
AMERICAN BLOWER CORPORATION, DETROIT 32, MICHIGAN
CANADIAN SIROCCO COMPANY, LTD., WINDSOR, ONTARIO
Division of American Radiator & Standard Sanitary Corporation



HS and Sirocco Fans for forced or induced draft in all types of power plants.



ST Fly Ash Precipitators—especially for power plants burning pulverized fuel.



Type VS Gyrol Fluid Drive—for adjustable speed control of mechanical draft fans.

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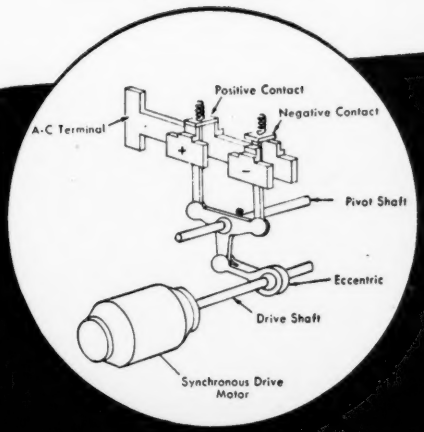


See how simple it is to get

DIRECT CURRENT *at* LOW VOLTAGES with the I-T-E MECHANICAL RECTIFIER

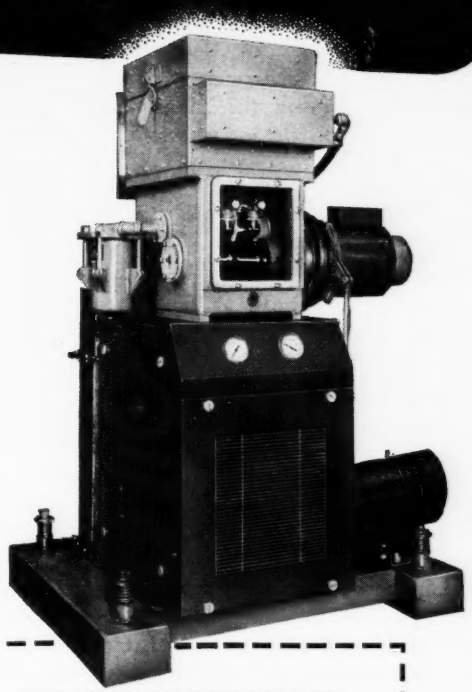
Simplicity is the key to the higher efficiencies of the I-T-E Mechanical Rectifier. Take a look at the mechanism illustrated.

All it consists of is a rocking arm driven by a synchronous motor. The arm carries contacts which make and break the alternating current circuit. Meanwhile, special reactors wound on I-T-E's "Permeron"— a magnetic alloy specially developed for this purpose — introduce a "step" into the conventional sine wave, allowing the contacts time to make and break when the current is zero.

Thus, there is no arcing, no sparking. And, with the contacts in operation while the current is flowing, there is practically no voltage drop — efficiency is over 95 per cent.

In actual service, a unit rated at 3500 amperes has been operating in the plant of the Buffalo Electro-Chemical Company, Buffalo, N. Y., since February 8, 1949, with the efficiency of 96.5 per cent! This unit has carried 5000 amperes at 260 volts d-c.

Get the complete story: You'll find complete technical information, including a detailed presentation of operating principles, in I-T-E's Bulletin 4809. Send for it today. The I-T-E representative in your locality will be glad to advise you on adapting the I-T-E Mechanical Rectifier to your specific needs. Consult him without obligation.



NOTE THESE ADVANTAGES ALSO:

- X ***Reduced size.*** A typical plant layout will show space savings of up to 50 per cent.
- X ***Simplified maintenance.*** No complicated tools or instruments are needed for servicing the new I-T-E Mechanical Rectifier.
- X ***Low over-all cost.*** Unit assembly at factory reduces installation costs. No special structural foundations are needed.

MECHANICAL RECTIFIERS

I-T-E CIRCUIT BREAKER COMPANY

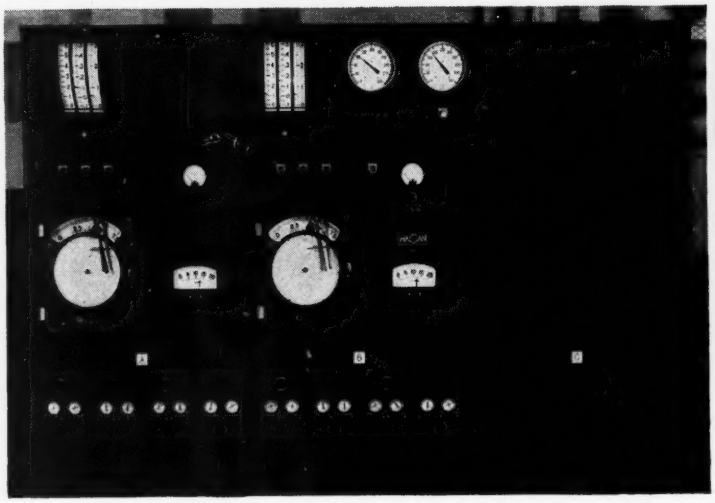
19TH & HAMILTON STREETS, PHILADELPHIA 30, PA.

CIRCUIT BREAKERS • SWITCHGEAR • UNIT SUBSTATIONS • ISOLATED PHASE BUS STRUCTURES • MECHANICAL RECTIFIERS

New boilers equipped with HAGAN Controls and Meters at JOHN B. STETSON CO.

In 1865, John B. Stetson, hatmaker, occupied one small building in Philadelphia. Today, John B. Stetson Company is the world's largest manufacturers of fine hats for men and women, with plants in Philadelphia, New York, Danbury, Conn., and Brockville, Canada. Stetson hats have become part of the American legend,—in the ballads and stories of the southwest, every hero's hat is a Stetson.

Recent modernization of the Stetson Philadelphia plant included the installation of two oil fired boilers, with provision for a third—and this installation includes Hagan Combustion Control and Hagan Ring Balance Boiler Meters.



Control Panel, showing three-pen indicating, recording and integrating Hagan Ring Balance Boiler Meters. Panel provides space for meter and control for a third boiler, to be installed later.

Steam is used in the hat making process, and to drive air compressors, vacuum cleaners and auxiliary equipment in the plant, and for heating the many large buildings which comprise the Philadelphia factory. The company also generates its own power.

The Combustion Control at the Stetson plant is a standard Hagan pneumatic system, including steam pressure furnace draft, and fuel-air ratio controls. Boiler meters are of the dual ring indicating, recording and integrating type, providing records of steam flow, air flow and stack temperature.

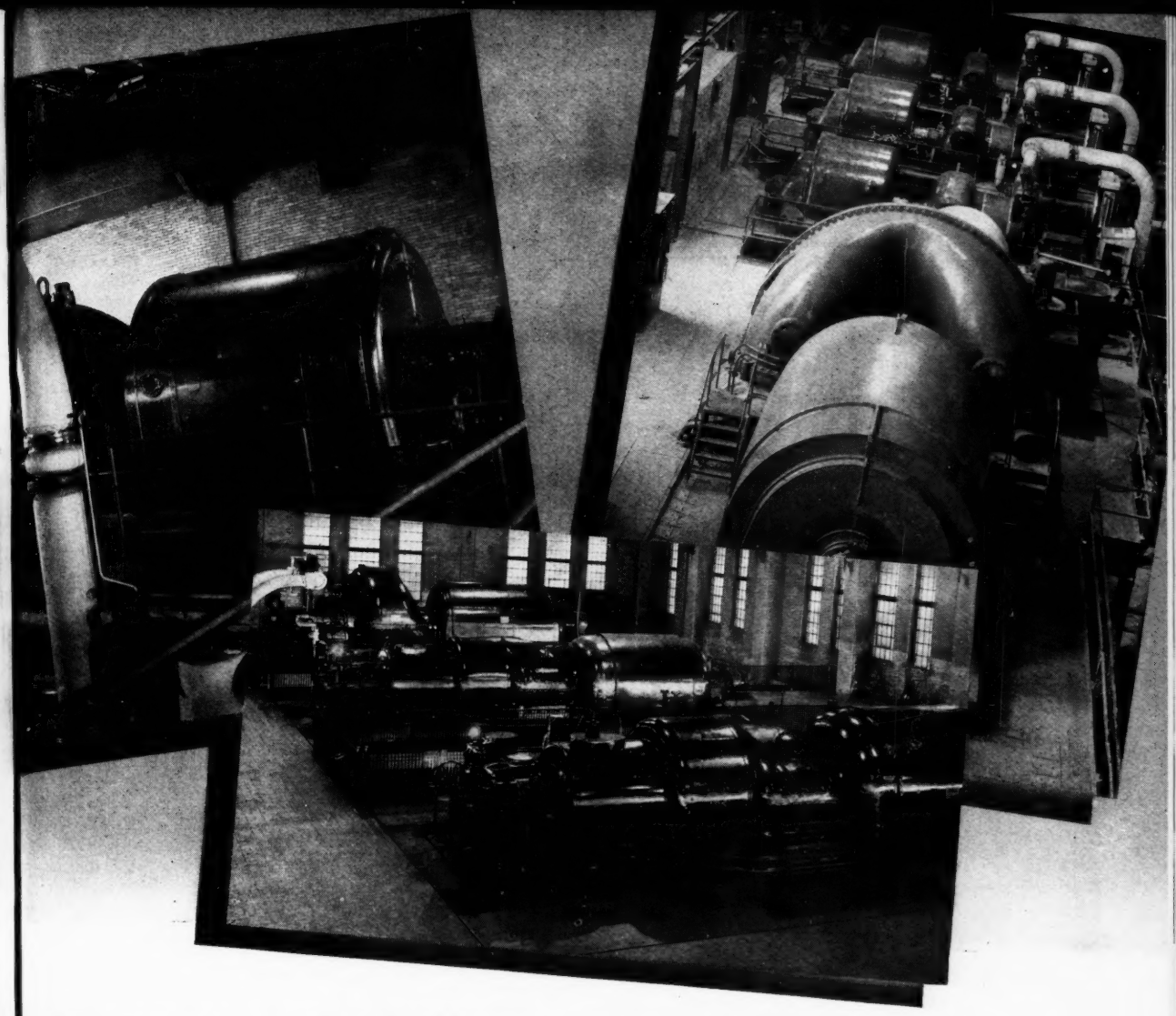
Hagan Controls and Hagan Ring Balance Meters are in service in plants of all types and sizes, in newly-built plants, and in modernized plants of long-established companies such as Stetson. For full information on these controls and meters, write to Hagan Corporation, Hagan Building, Pittsburgh 30, Pennsylvania.

General view of boiler room. United Engineers and Constructors, Inc., Philadelphia, Pa., were engineers and contractors on this installation, working with Stetson engineers.

HAGAN HALL BUROMIN CALGON

HAGAN CORPORATION

RING BALANCE FLOW AND PRESSURE INSTRUMENTS
THRUSTORQ FORCE MEASURING DEVICES
BOILER COMBUSTION CONTROL SYSTEMS
METALLURGICAL FURNACE CONTROL SYSTEMS



21-year record shows economy of...

WHEN A LARGE COMPANY uses one turbine oil for over 21 years and in an increasing number of units, it's worth knowing why!

In 1927, the Carnegie-Illinois Steel Corporation put Nonpareil Turbine Oil into a 30,000 KW General Electric turbine. Today, this company lubricates sixteen turbines, having a total capacity of nearly 200,000 KW, with Nonpareil. What's back of the impressive acceptance of this turbine oil?

Here's the 21-year record for the company's first Nonpareil-lubricated turbine: *No oil replaced, no oil removed for treating, no need to clean the oil system.*

Such economical and reliable turbine lubrication has kept Carnegie-Illinois Steel officials completely sold on Nonpareil. Why not make their experience your basis for investigating Nonpareil's advantages? A Standard Oil Lubrication Engineer will supply you with information about utility operations on which Nonpareil has reduced lubrication costs as much as 68%.

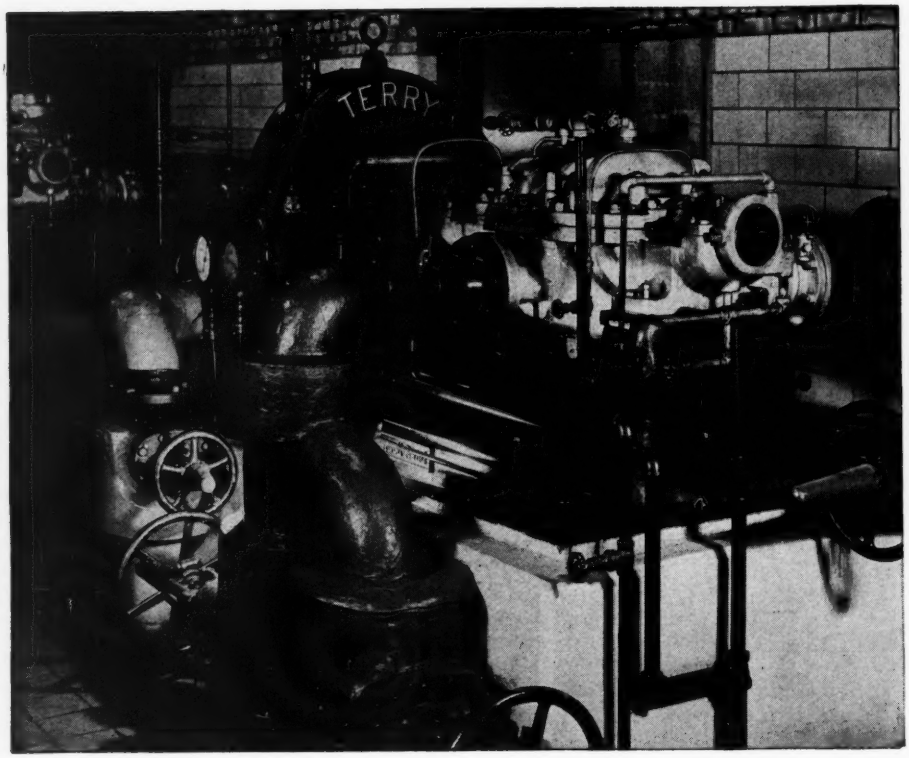
NONPAREIL
Turbine Oil

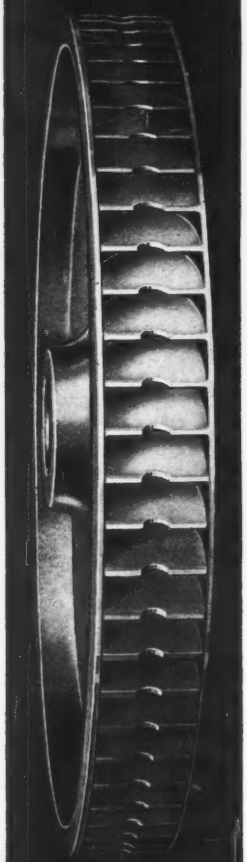
"Will outlast your turbine"

Write Standard Oil Company (Indiana), 910 South Michigan Avenue, Chicago 80, Ill.

STANDARD OIL COMPANY (INDIANA) STANDARD

TERRY





110hp Feed Pump Turbine with Large Safe Clearances

The blades of this turbine are milled out of a one-piece forged-steel wheel with generous clearance both radially and axially. The side clearance is very large — one inch — and the blades are protected by a projecting rim on each side of the wheel. It is therefore impossible for the blades to foul and end play can do no damage to the turbine.

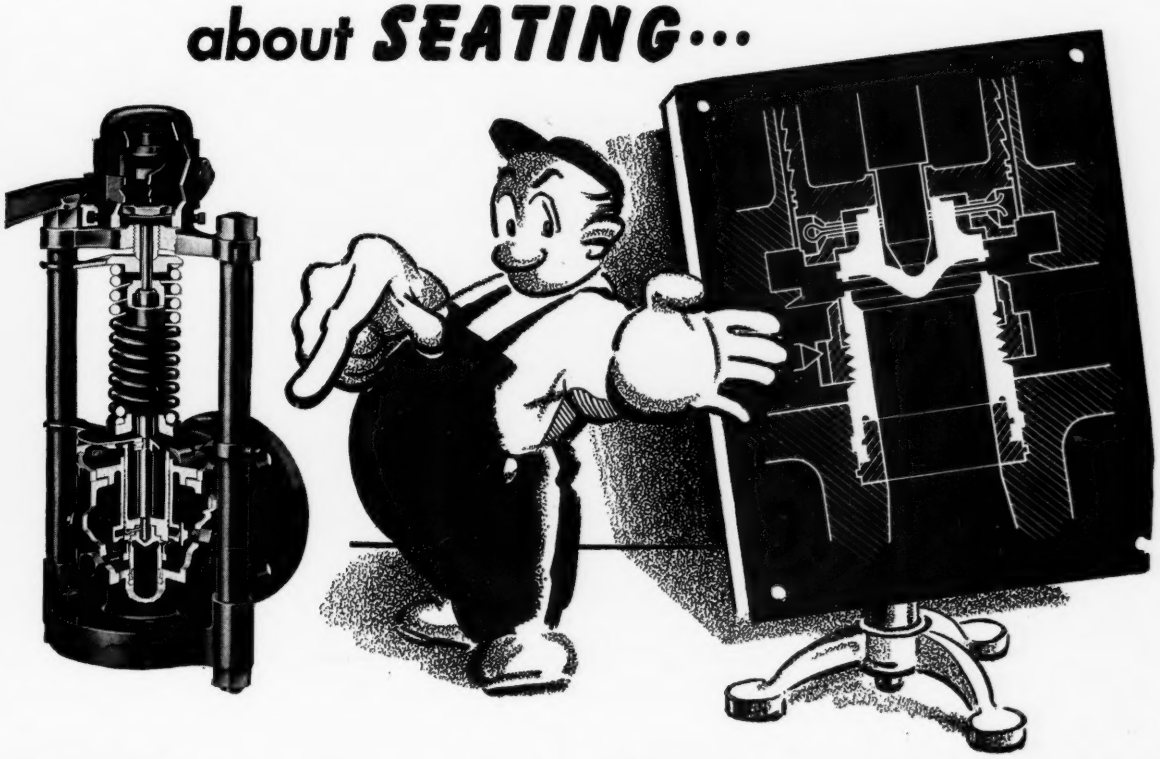
These are but a few of the features that make the Terry Solid-Wheel Turbine such a dependable driver. A bulletin giving other interesting facts about this turbine will be sent upon request.

T 1179

THE TERRY STEAM TURBINE COMPANY
TERRY SQUARE, HARTFORD, CONN.

We Studied SAFETY VALVE LEAKAGE

— Here's what we found out about SEATING...



We found — what most power plant men already know...that in order to be tight, a safety valve must have matched, wear resistant, corrosion resistant seating surfaces, and that the disc must seat square.

We found — what power plant men have long suspected...that uneven expansion, causing dragging of one seating surface over the other, can destroy the seat so completely that the safety valve has to be overhauled or replaced, even though it has never been popped.

We found ...that when nozzle and disc are made of alloys with the same coefficient of expansion, and with sections designed so that their rate of heat absorption is the same, destructive drag is eliminated. This is one of the basic features of the Gentzel Design, and is the reason Foster 38-SV Safety Valves can be guaranteed to stay tight.

To you ...this means elimination of costly boiler outage due to safety valve leakage. Other guaranteed *and* proven advantages are...consistently accurate popping ...minimum blow-down, which can be held to as little as 1%...highest relief capacity for a given nominal valve size...and extremely low maintenance.

For full details on the design and construction features that enable this valve to outperform ANY other safety valve, get in touch with your Foster Representative or with us direct.

FOSTER ENGINEERING Company

PRESSURE REGULATORS...RELIEF AND BACK PRESSURE VALVES...AUTOMATIC STOP AND CHECK VALVES...ALTITUDE VALVES...DAMPER REGULATORS...FAN ENGINE REGULATORS... PUMP GOVERNORS...TEMPERATURE REGULATORS...LIQUID LEVEL CONTROLLERS...FLOAT AND LEVER BALANCED VALVES...NON-RETURN AND TRIPLE DUTY VALVES...VACUUM REGULATORS OR BREAKERS...SIGHT FLOW BOXES...STRAINERS...SAFETY VALVES...SIRENS

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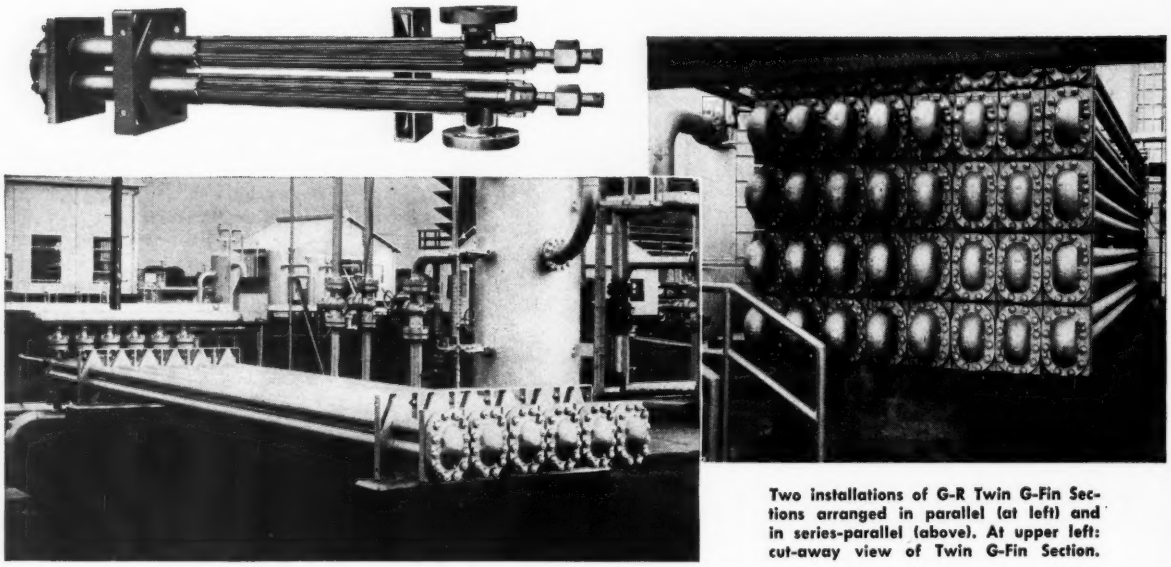
16 YEARS OF PROVEN PERFORMANCE • **50,000 INSTALLED UNITS**

• **WIDEST ADAPTABILITY OF ANY HEAT EXCHANGER**

Three Compelling Reasons Why You Should Investigate The

G-R TWIN G-FIN SECTION



Two installations of G-R Twin G-Fin Sections arranged in parallel (at left) and in series-parallel (above). At upper left: cut-away view of Twin G-Fin Section.

If your plant requires a heater, cooler or heat exchanger, consider the record of the G-R Twin G-Fin Section. Here is a heat transfer apparatus that is:

SIMPLE . . . it consists essentially of one pipe within another, without the complications of tube sheets, baffles, or internal joints.

EFFECTIVE . . . the patented longitudinal G-Fins on the outside of the inner pipe provide an extended surface that compensates for the unequal heat transfer rates of dissimilar fluids such as oil and water or steam and process liquids.

ECONOMICAL . . . it is a stock design, easily installed, sturdily built for long life, requiring no attention, with negligible maintenance expense.

ADAPTABLE . . . units are standard and interchangeable, can be made of either ferrous or non-ferrous metals or alloys, can be used as a heater, cooler, condenser or heat exchanger for practically all liquids, vapors and gases, and can be readily converted from one service to another.

These advantages have been proven by installations totalling more than 50,000 units during the last 16 years, serving a greater variety of heat transfer requirements than any other design on the market. Most likely a G-R Twin G-Fin Section will improve one or more heat transfer operations in *your* plant. Write for Bulletin 1614 describing these units in detail.

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For Pressures up to 900 Pounds

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ALIGNMENT & STIFFENER ROD

NO GAGE GLASS PACKING NUTS

No Tools Required to Change A Gage Glass

WATER LEVEL VISIBLE FROM BELOW

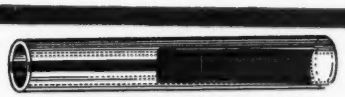
ERNST INSERTS "C-CLEAR THRU" AND REFLEX TYPE

GUARDS WIRE GLASS AND PLASTIC

FIG. 9

FIG. 72

FIG 1
High and Low Alarm Column Split-Gland Gage Inclined.



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ROUND-TUBULAR clear & red-line magnifying
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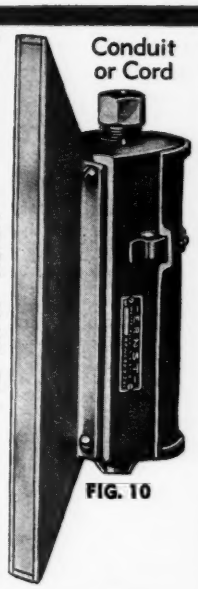

FIG. 10

Non-Glare
"PLAIN SIGHT" ILLUMINATORS
give a clear, distinct reading of water level.

ERNST WATER COLUMN & GAGE COMPANY
[illegible] TELEPHONE: [illegible]

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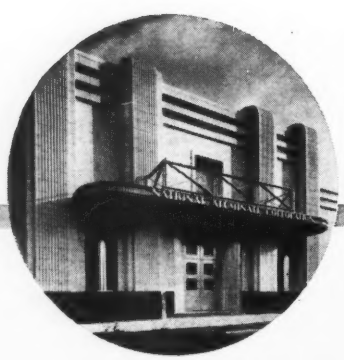

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Call your nearest Dowell office today and find out about rapid, convenient, economical Dowell Chemical Scale Removal Service for heat exchange equipment, boilers, condensers, water-lines—and for increasing water well output. Free cost estimates are gladly given.

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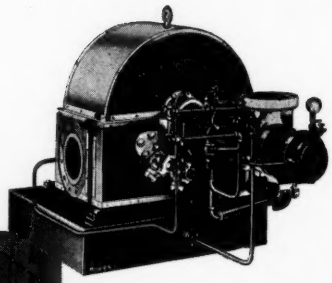
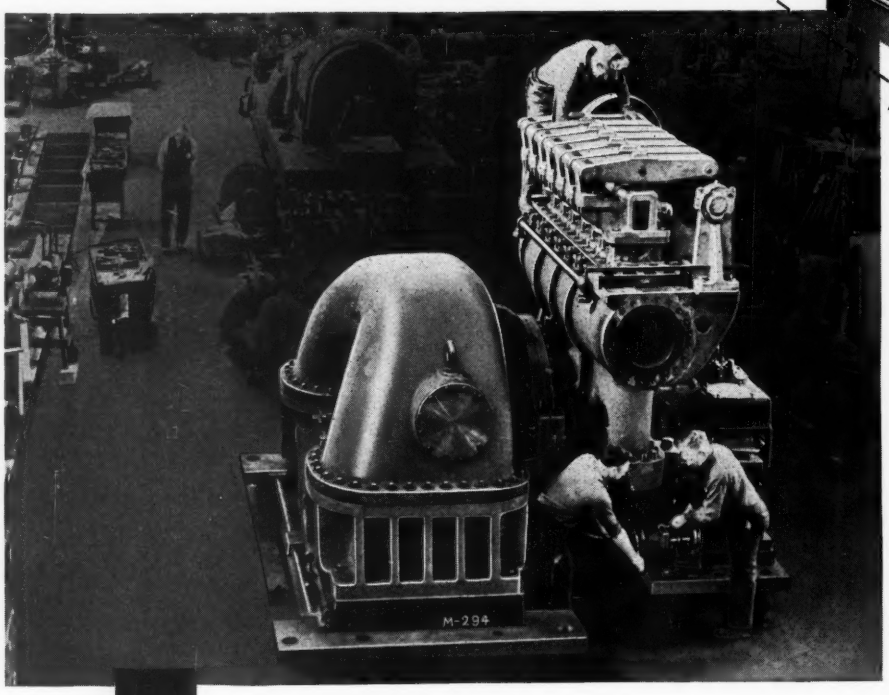


FROM SMALLEST SINGLE-STAGE



TO MULTI-STAGE GIANTS

A standout for size. One of two Worthington 24,000 hp centrifugal compressor-drive turbines during assembly.

Worthington Turbines Meet the Broadest Range of Drive Requirements

Worthington Turbines offer you unlimited choice of sizes and types — including straight condensing, straight non-condensing, extraction, mixed pressure extraction, low pressure and high back pressure. Steam or gas driven, for mechanical or generator drive, all are available with governors for constant or variable speed, with optional governor-control

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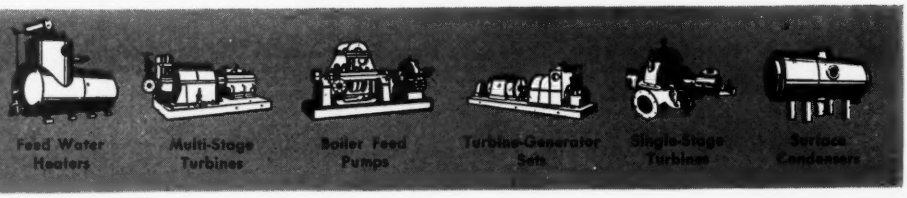
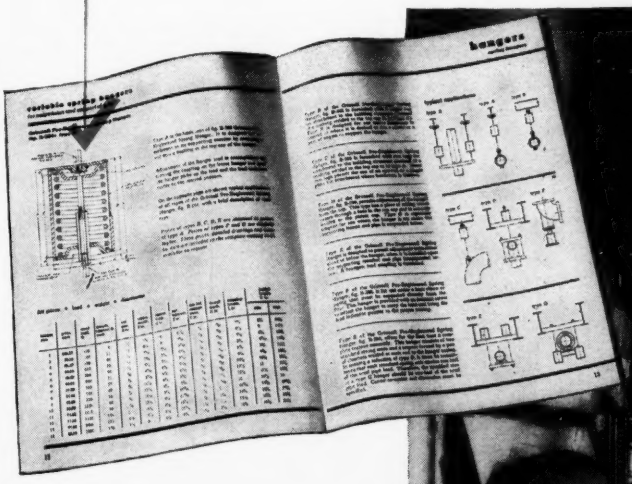
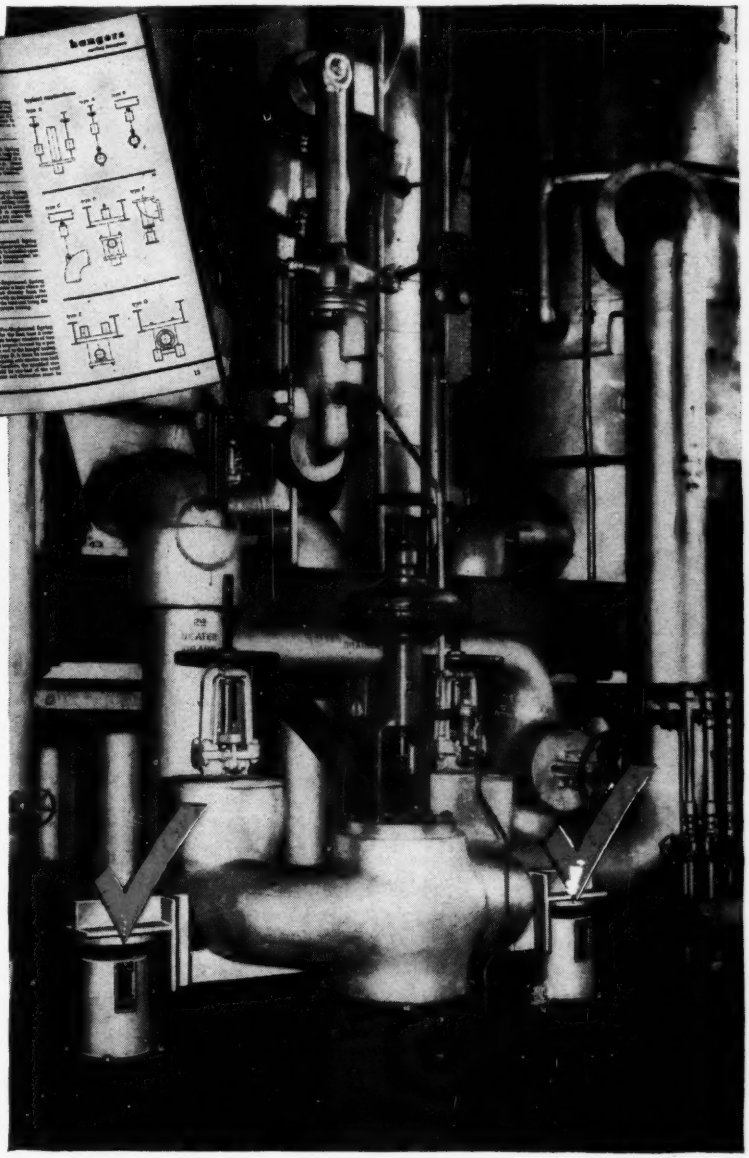
TS-3

A GREAT TEAM IN STEAM



The problem was "special" but the solution came "out of stock"





Tons of heater drain piping in the turbine room of the new Southwark station of the Philadelphia Electric Company had to be supported somehow. It had to be flexibly supported because of the travel between its "hot" and "cold" positions. The ceiling was sixty feet up so overhead suspension was out. Could it be supported from the floor? The problem had already been anticipated by Grinnell with their Pre-Engineered Spring Hanger fig. B268: type F, described in the new Grinnell Pipe Hanger Catalog 10D. This hanger is available in 14 sizes with a range of load capacities from 74 to 4800 lbs.

Plenty of other piping support problems are pre-solved economically for you in this combination catalog and manual . . . with ready-to-install hangers and supports . . . all available from conveniently located Grinnell warehouses. Why not write today for your copy of Catalog 10D?

99 YEARS PIPING

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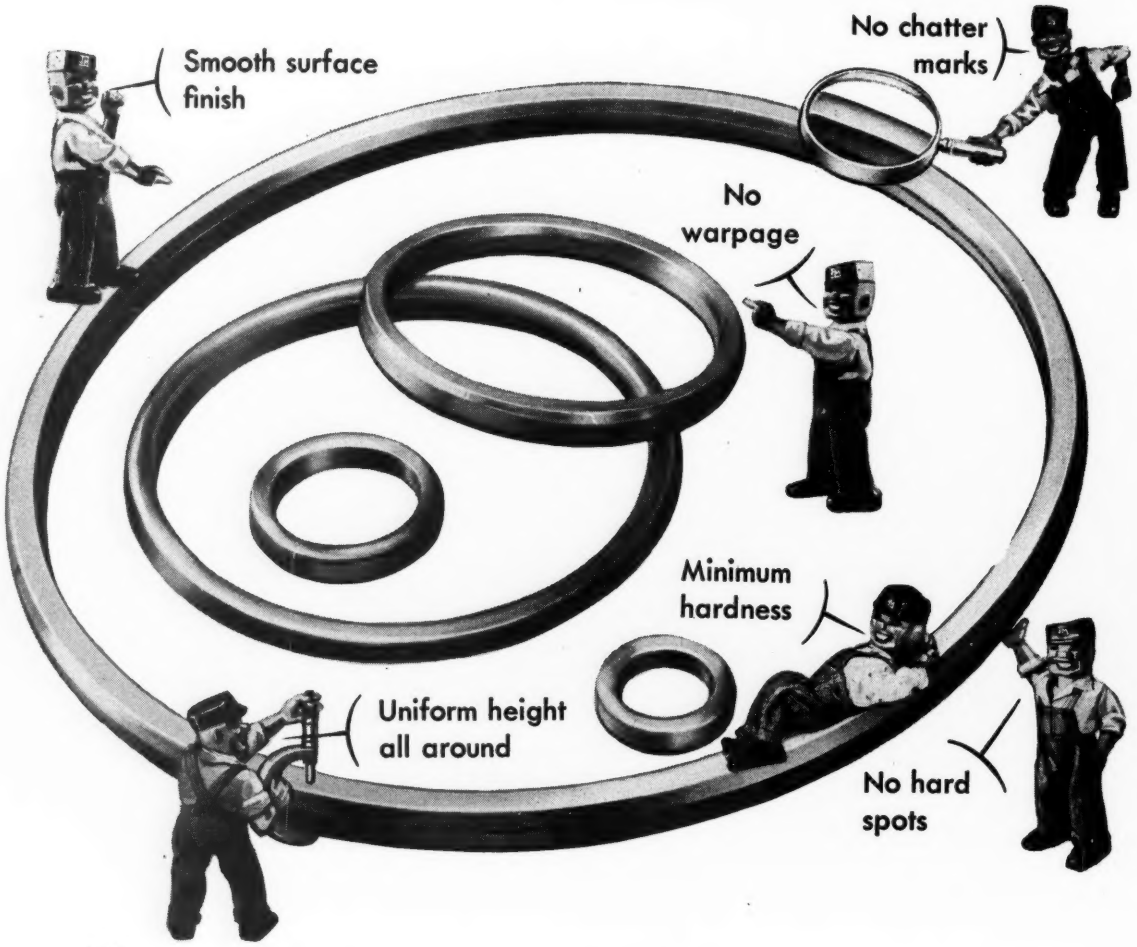
Grinnell Company, Inc., Providence, Rhode Island. Branches: Atlanta • Buffalo • Charlotte • Chicago • Cleveland • Cranston • Fresno • Kansas City • Houston Long Beach • Los Angeles • Milwaukee • Minneapolis • New York • Oakland • Philadelphia • Sacramento • St. Louis • St. Paul • San Francisco • Seattle • Spokane



Made "soft" for proper flow ... Made accurate for perfect fit!

Goetze V-Tite Gaskets for ring-type joint flanges

One sure way to tell quality in a gasket designed for ring-joint flanges is to check the hardness. In Goetze V-Tites, carefully controlled heat treatment during fabrication keeps hardness down to a minimum. The hardness of a Goetze soft iron V-Tite Gasket, for example, does not exceed 90 Brinell.

And because each gasket is uniformly "soft" throughout (you'll find no hard spots in a Goetze V-Tite), proper flow or seating of the gasket, without damage to flange surfaces and with minimum bolt stresses, is always assured.

Dimensional accuracy is also important in a ring-type gasket. Here, too, Goetze V-Tites meet high precision standards. They are of uniform height all around . . . free of warpage . . . have the same center-to-center measurements top and bottom . . . other tolerances are well within API and ASA specifications to assure a perfect fit in the flange grooves.

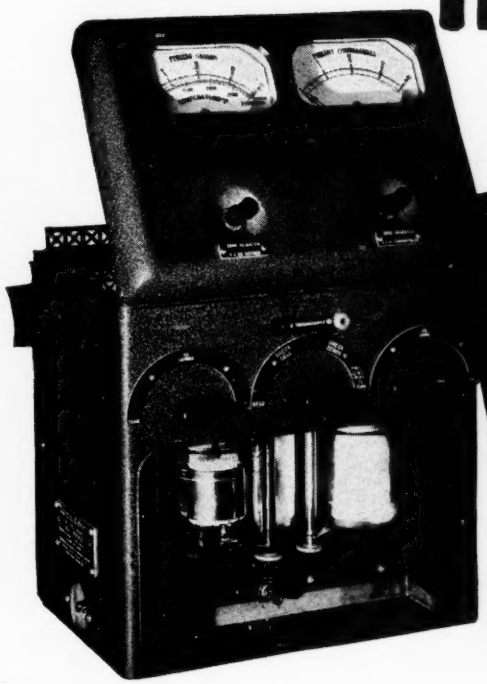
In addition to soft iron, Goetze V-Tite Gaskets are made in a number of alloys in all standard ASA and API shapes and sizes. Gaskets of special dimensions are also available. For further details, write for Catalog PK-35A. Johns-Manville, Box 290, New York 16, N. Y.

JOHNS-MANVILLE JM PRODUCT

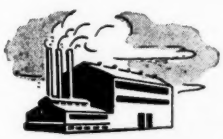
Johns-Manville Goetze Gaskets

THERE'S A JOHNS-MANVILLE PACKING OR GASKET FOR EVERY SERVICE

this unique instrument

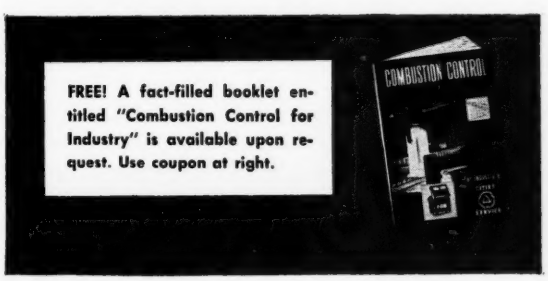


SHOWED US how to increase power generation by 15%



"Using the identical equipment, the same type of fuel, and at no extra cost—we increased our power output as much as we might have gained with an additional new unit. We accomplished this with a few simple adjustments which we made upon the advice of a Cities Service representative after an analysis with the Industrial Heat Prover."

THE INDUSTRIAL HEAT PROVER is a flue gas analyzer. It tells quickly, accurately and continuously how much fuel is wasted by needlessly heating excess air . . . and how to correct this loss. There is no charge or obligation to you for a demonstration of this service. If you feel that your operation could profit from scientific control of combustion, get in touch with our nearest office or write for the free new booklet below.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CITIES SERVICE

NEW EQUIPMENT NEWS

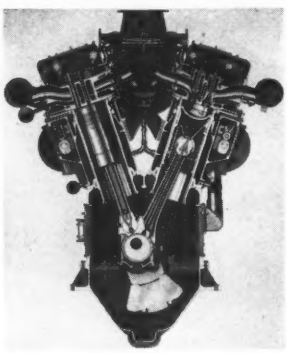
WHAT'S NEW? On these pages the Editors summarize the outstanding industrial developments of leading manufacturers who will supply you, free of charge, the bulletins or other information desired. For ease in making requests use the no-obligation, postage-paid card pages 35-36.

1—LARGE V-TYPE DIESEL

Is compact, 16-cylinder unit designed to develop 3,300 hp

Pictured here—in its proper position—is The Cooper-Bessemer Corp.'s LSV engine, designed to operate as an oil burning Diesel gas engine or a gas Diesel unit. This engine was described in a recent issue of POWER GENERATION, but the accompanying picture showed the engine standing on its head!

The error was caught by several red-faced editors immediately after it was too late to do anything about it. Readers noticed it, of course, and some



wrote letters, including one engineer who asked politely if the "inverted V-type Diesel" were something new.

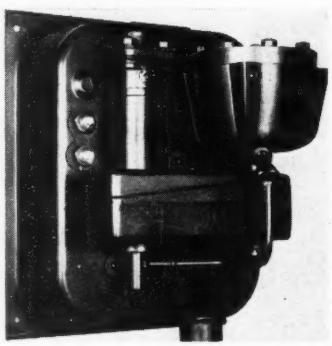
When the designers of this engine saw its picture they must have thought it "something new," too. So to them, and to other members of Cooper-Bessemer's engineering staff go sincere apologies for the unconventional installation of their LSV Diesel.

2—FLOW METER

Features a magnetic clutch to transmit movement of the float

The magnetic clutch principle by which the Magna-Clutch Flow Meter operates is not new, having been used in Europe, it is pointed out. But the development of such meters in this country was hampered by unavailability of high powered magnets and non-magnetic metal wall material of high tensile strength, both now obtainable.

More power with less friction is claimed for the meter because of its large float (3.75 in. dia) and long float travel (1.5 in.) Movement of the float is transmitted through a pressure tight manometer by means of the magnetic clutch. This construction is designed to eliminate friction, leakage and maintenance and provide sustained accuracy.

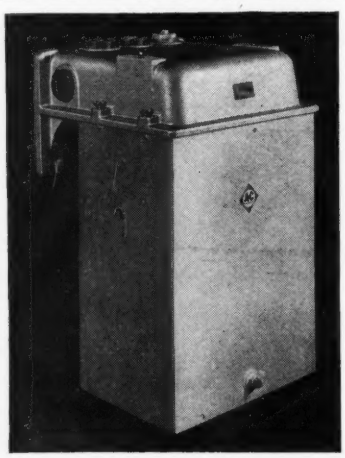


Five adjustable range tubes give rangeability from 17 to 750 in. water differential. Working pressures are given as 1500 psi and 2500 psi (convertible in the field). Six types or combinations of recording, indicating and integrating meters are offered. The Hays Corp.

3—FULL-VOLTAGE STARTER

For use in combustible dust laden atmospheres, around corrosive vapors

A wall-mounted full-voltage starter—Type 371— is said to be especially adaptable for use in chemical, liquid fuel, milling, coal handling. The new starter has its entire mechanism immersed in oil and sealed from the atmosphere. It is weather-proof and can be used for outdoor installations, manufacturer states, adding that starter enclosure is corrosion resistant; the head casting is of aluminum alloy, exposed hardware is stainless steel, and the steel tank is coated with aluminum paint on the outside and marine spar varnish within.

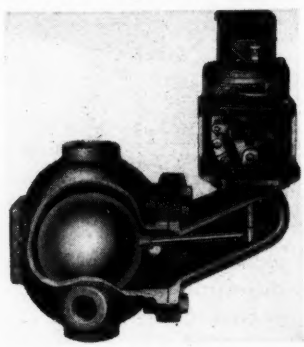


Built for simple installation and easy inspection, the starter controls squirrel cage motors and the primary of wound rotor motors of 350 hp or less at 2300 v. It is acutated by a pilot device, such as push buttons, float, pressure switches, or similar devices. Either undervoltage protection or release may be incorporated in the control circuits used in conjunction with the starter. A built-in drum type multi-stage auxiliary switch provides for extra circuits when desired in the control system. A portable tank lifter for simplified inspection is available as optional equipment. Allis-Chalmers Mfg. Co.

4—LOW WATER CUT-OFF

For automatically fired boilers carrying up to 50 lb pressure

The No. 63 low water cut-off can be used on steam boilers, but was designed primarily for hot water heating boilers, for installation with 1-in. equalizing piping. Manufacturer also recommends it for automatically fired steam boilers in the 20 to 50 lb pressure range.



Like company's No. 150 cut-off for pressures up to 150 lb, the No. 63 has working parts isolated from heat of float chamber; sylphon bellows, out of the water; other working parts of non-corrosive materials. Switch proper is manufacturer's No. 2 snap action type. McDonnell & Miller, Inc.

5—A-C STARTERS

Are manually operated, designed for use on motors up to 7½ hp

These starters are specially designed for use on small pumps, blowers, and grinders. Available immediately, they are furnished in both toggle and push-button types in 2-, 3-, and 4-pole forms, Size 0 and 1. The toggle operated types in the above forms and sizes are

USE THE NO-OBLIGATION, POSTAGE-PAID CARD ON PAGES 35-36

For complete selection . . . better service

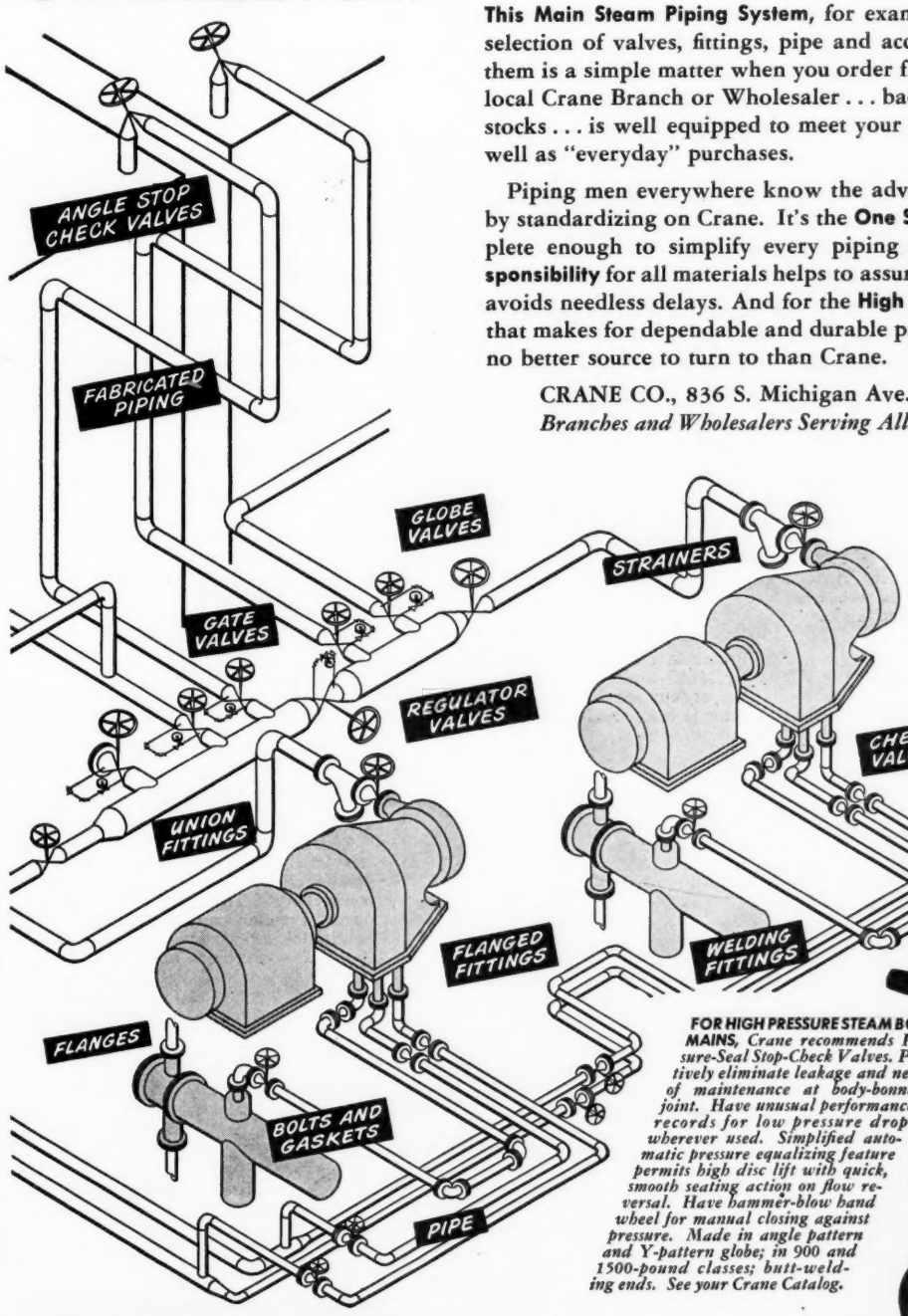
ONE SOURCE OF SUPPLY
RESPONSIBILITY
STANDARD OF QUALITY

Look to the CRANE line

This Main Steam Piping System, for example, requires a wide selection of valves, fittings, pipe and accessories. Yet getting them is a simple matter when you order from Crane. For your local Crane Branch or Wholesaler . . . backed by large factory stocks . . . is well equipped to meet your needs—infrequent as well as "everyday" purchases.

Piping men everywhere know the advantages to be gained by standardizing on Crane. It's the **One Source of Supply** complete enough to simplify every piping procedure. **One Responsibility** for all materials helps to assure better installations, avoids needless delays. And for the **High Quality** in every item that makes for dependable and durable piping systems, there's no better source to turn to than Crane.

CRANE CO., 836 S. Michigan Ave., Chicago 5, Ill.
Branches and Wholesalers Serving All Industrial Areas



Main steam lines in a large power plant; one order to Crane gets all piping equipment.

FOR HIGH PRESSURE STEAM BOILER MAINS, *Crane recommends Pressure-Seal Stop-Check Valves. Positively eliminate leakage and need of maintenance at body-bonnet joint. Have unusual performance records for low pressure drop wherever used. Simplified automatic pressure equalizing feature permits high disc lift with quick, smooth seating action on flow reversal. Have hammer-blow hand wheel for manual closing against pressure. Made in angle pattern and Y-pattern globe; in 900 and 1500-pound classes; butt-welding ends. See your Crane Catalog.*

EVERYTHING FROM . . .

VALVES • FITTINGS
PIPE • PLUMBING
AND HEATING

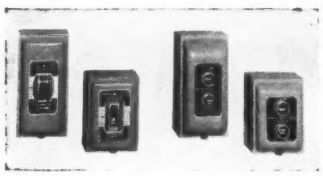
CRANE

FOR EVERY PIPING SYSTEM

Mark the numbers of the items you wish to receive on the no obligation, no postage card. Pages 35-36.

also furnished, if desired, with cast iron enclosures for use in wet, dust-laden, or hazardous locations.

A feature of these starters is their bimetallic overload protection, intended to replace the solder-pot relay and provide exceptionally accurate response

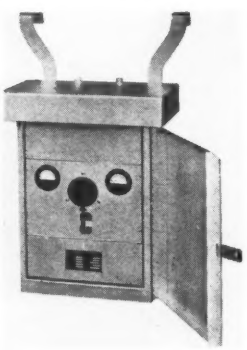


to overloads. In addition, the starters are equipped with a wide range of heaters, all of which follow closely the motor heating curve. Positive indication of overload trip is said to be assured by the toggle or push-button, which assumes a neutral position when the relay trips. All starters in general purpose enclosures can be padlocked. Live parts are mounted on a molded base of high insulating quality. Heaters are enclosed in a cavity in the base. Control Divs., General Electric Co.

6—SELENIUM RECTIFIER

Is cathodic protection unit with several original features

In these units special emphasis has been placed on high temperature operation. High-ambient selenium rectifier stacks are convention-cooled or



oil-immersed, to provide long life of unit and complete pipe or tank protection. For locations where extremely high temperatures are encountered, transite housings are available.

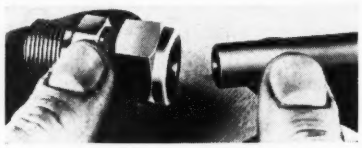
All units contain a continuously variable transformer for fine adjustment of the output voltage. Rectifier embodies a hinged dead front meter panel to provide personnel protection with easy access to components.

Model illustrated has a-c input of 110 v and d-c output of 36 amp at 15 v. Output is continuously variable from 0 to 15 v with circuit protection provided for a-c input and d-c output. Industrial Electronics and Transformer Co.

7—TUBE FITTING

Is clinch type, for use with any metal or plastic tubing

Marketed under the trade name Swagelok, these new fittings are designed to provide leak-proof seals at three points. Two ferrules and a threaded chuck clamp around a tube with virtually no effect on the inner walls, thus leaving the flow of liquids or gases completely unimpeded according to manufacturer, and tests have indicated that tubing



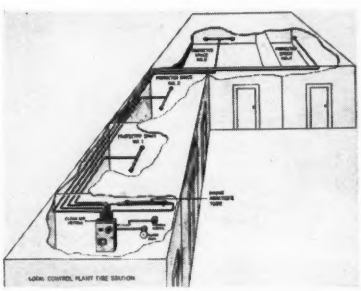
will burst before these fittings themselves will leak.

A Swagelok is slipped onto the end of a tube and given one-and-one-quarter turns with any standard wrench. The resulting assembly is then ready for service. No damaging torque or twisting is transmitted to the tube during this brief tightening operation, it is pointed out. Swageloks may be obtained in Monel, brass, aluminum, steel and stainless steel, Types 303 and 316. Connectors, unions, elbows and "tees" are all being produced, in a range of sizes that permit their use with tubing $\frac{1}{8}$ to 1 in. OD. Crawford Fitting Co.

8—SMOKE DETECTOR

Polices several plant areas simultaneously for fire

By means of a selector valving system the Multi-Space Smoke Detector will protect four spaces simultaneously. Detector is comprised of two main units—



control cabinet and analyzer tube. The cabinet contains an electrical panel with automatic supervisional circuits, constant voltage transformer, exhauster fan, and motor-driven selector valving system.

In each protected area or zone, one or more accumulators — depending on area and arrangement of space—are installed at the ceiling. These accumulators are connected to rigid piping that leads to the control cabinet, preferably located at some point central to the protected areas. The analyzer tube is mounted near the control cabinet and is connected to it electrically and by piping. Fire alarm and trouble signals or bells may be located at one or more points.

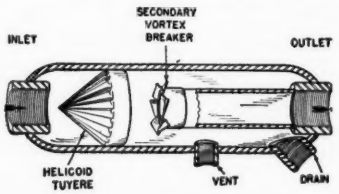
If 3 per cent or more smoke is present in any air sample, the valving mechanism stops and the fire alarm rings. The numbered zone wheel, visible through window in control cabinet door, indicates space from which alarm originates. The remote indicator tells the exact location where smoke is present. Concentrations of smoke lower than 3 per cent set off a trouble alarm, which changes into fire alarm as smoke density increases. Walter Kidde & Co.

9—AIR-STEAM LINE PURIFIER

For removing foreign matter from compressed air and steam lines

The Type RA line purifier designed to remove oil, water, pipe scale, rust and sediment from compressed air and steam lines is said to be particularly valuable for cleaning air used in air-operated machinery, and for purifying steam to protect equipment and product. Unit may also be used to obtain perfectly clean, dry steam in steam processing.

This purifier features a new-type helicoid tuyere, constructed of monel or stainless steel, described as effecting



positive separation of entrainment and removing up to 99 per cent of moisture. The centrifugal principle upon which the line purifier operates is initiated as the stream enters the line purifier body and engages the tuyere, the blade-like flutes of which direct the stream into a special whirling mass. The design of the tuyere combined with centrifugal force leads solids to outside of tuyere and the inside wall of the purifier body.

Clean, dry gas or vapor passes through the center outlet pipe, while the heavier particles of moisture and solids flow down the inside wall of purifier to drain pocket and out the drain.

Constructed of forged steel, the purifier is rigid, compact, and easily installed with threaded inlet and outlet connections. There are no moving parts. Purifier can be used in either horizontal or vertical downflow position. The purifier, according to the manufacturer, is designed for use on steam lines up to 400 lb gage and 650 F, and for compressed air or gas not exceeding 800 lb gage and 100 F nonshock service. Centrifix Corp.

10—PYROMETER CONTROLLER

Is electronic instrument for medium and high temperature use

Here's an electronic controller, designed for use where precise control is needed or where vibration is severe, but the added cost of indicating or recording is not justified.

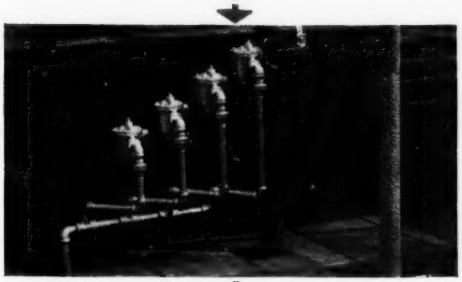
A thermocouple sensitive element is used. The measuring circuit is a null balance potentiometer with automatic cold junction compensation. Frequency of standardizing is reduced by a new battery and circuit. Thirteen standard measuring ranges are available.

Unbalance voltages are converted to a-c and amplified electronically. Control action is continuous and high speed. Two-position control relay is operated directly by amplifier through trigger circuit for high sensitivity with anti-chatter circuit for positive action. Loudon Instruments, Inc.

"This Trap can't leak steam . . ."

YOU SAVE MONEY

$300 PER MONTH fuel saving with 17 Armstrong traps on jacketed kettles and expeller tempering troughs. The traps cost $316. More than 1000% return per year! — *Pacific Nut Oil Co., Los Angeles.*



20% FUEL SAVING since installing 57 Armstrong traps on heating coils makes the coal pile last longer at *Norton Greenhouse, St. Paul.* Heating-up time has been cut in half, too.

THERE is never any loss of steam through an Armstrong Trap in proper working order, even when there is no condensate load . . . because steam never reaches the discharge orifice. The valve is water-sealed at all times. Entering steam is trapped in the inverted bucket, which then floats and closes the valve.

RESULT: You save steam, fuel and money, minimize back pressure in your return lines.

Your nearby Armstrong representative will be glad to quote on the traps you need now.

ARMSTRONG MACHINE WORKS
810 MAPLE ST., THREE RIVERS, MICH.

SEND FOR the Armstrong Steam Trap Book. It describes operation of the Armstrong Steam Trap, contains prices, data, capacity chart, trap selection data for all classes of equipment.

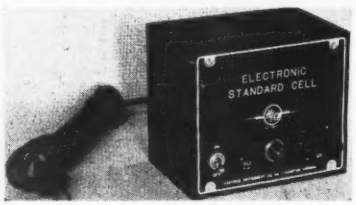
ARMSTRONG STEAM TRAPS

Mark the numbers of the items you wish to receive on the no obligation, no postage card. Pages 35-36.

11—ELECTRONIC CELL

For instrumentation requiring accurate, highly stable d-c voltage

This Electronic Standard Cell is available for any specified d-c output voltage from 0 to 100 and for any load up to 30 ma. Output voltage is said to be constant to better than 0.1 per cent and with ripple less than 0.1 per cent throughout an input range of 75 to 135 v a-c at frequencies from 50 to 400 cps.



Cell is described as not subject to freezing and usable over a wide temperature range. It is not damaged by momentary short circuits, and can be used either as reference voltage in bridge or potentiometer circuits or for supplying current continuously as an instrument power supply, manufacturer points out.

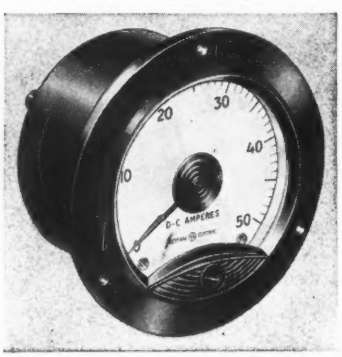
Cell is intended for use with self-balancing potentiometers, recording oscillographs, resistance thermometers, wire strain gages, position potentiometers and other instruments. May be used as individual instrument or as built-in component for larger instruments.

Precise output voltages or the usual standard cell voltage of 1.018 can be supplied. Hastings Instrument Co.

12—PANEL INSTRUMENTS

Long scale, in 3½ in. size, of internal pivot-type construction

Types DO-81 (direct current), DO-82 (thermocouple), and DO-83 (rectifier), panel instruments employ standard 3½-in. round and square cases with 250-deg scales 4.92 in. long for good readability. Designed for general industrial applications, as well as for electronic devices and testing equipment, the instruments have permanent-



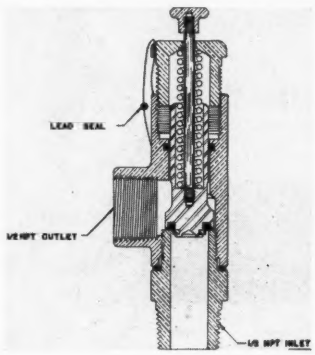
magnet, moving-coil mechanisms. With the exception of high-sensitivity microammeters, they are available in all ratings now listed for conventional 3½-in. instruments with 90-deg scales.

The complete line, said to fall into the 2 per cent basic accuracy class. Housed in molded Textolite cases, the instruments are made for flush mounting on non-magnetic or steel panels. Meter and Instrument Divs., General Electric Co.

13—FREON RELIEF VALVE

Is designed to seat tightly, even after repeated "popping"

In order to overcome the problem of Freon leakage, the CGA½-2 valve is engineered to assure a tight seating valve and to permit installation of a safety head rupture disc on the valve



outlet without impairing the proper opening of the valve. The possibility that bits of dirt or scale may lodge beneath the valve plug and keep it from closing tightly makes it wise, manufacturer points out, to use a safety head rupture disc with the valve. Black, Sivalls and Bryson, Inc.

14—WIRE ROPE SWIVEL

Has double roller bearings; is designed to swivel under full load

Features of this swivel include both thrust and radical roller bearings; streamlined bodies; heavy load capacity in relation to size; permanent lubrica-

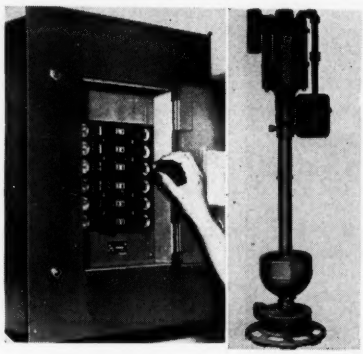
tion; replaceable parts. Swivels are offered in five sizes: for ½, ⅝, ¾, 1 and 1½ in. wire rope sizes. They can be had with four types of ends: eye-bolt, hook-bolt, integral eye or clevis. Flexo Machines Co.

15—LOW COST PANELBOARD

For group and branch circuit control of lighting distribution

This economical panelboard has a hot-molded phenolic section containing six complete circuits. This section is said to provide uniform, safe control and carry approval by Underwriters' Laboratories. It is available in 6 to 42 circuits.

The NTPR panelboard has been designed to fit standard stud walls without projections. Spacious wiring gutters and various sized knockouts are provided to permit different wiring arrangements. Current-carrying parts are silver finished to provide low resistance contact and assure long service life. Plug fuse receptacles will accommodate non-tamperable fuses. The Trumbull Electric Mfg. Co.



16—SUMP PUMP

For use in hazardous locations, has fully enclosed motor and switch

Series MC Automatic Electric Sumps are announced as explosion proof and having Underwriters' approval for use in atmospheres containing metal dust, carbon black, coal or coke dust, grain dust, gasoline, naphtha, alcohol, acetone, lacquer, solvent vapors and natural gas. Motor leads are connected to switch terminals through threaded conduit. Switch housing has ½ in. pipe size threaded outlet.

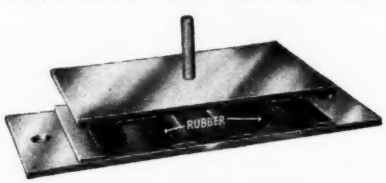
This pump has a nominal capacity of 4000 gph and is designed to operate against a 23 ft discharge head. Construction is copper and bronze; it cannot rust, manufacturer states. Switch is controlled by an extra heavy copper float, sliding freely on the supporting column. An adjustable stop governs water level at which the pump starts and stops. Pump is built in five lengths for sump depths of 2, 3, 4, 6 and 8 ft. All lengths available from stock for 110 v, 60 cycle, or 220 v, 60 cycle current. Penberthy Injector Co.

17—VIBRATION MOUNTS

For isolating horizontal and rotary machine vibrations

Finnflex CM-H Vibration Mount is designed for use with precision grinders, lathes, generators, pumps, compressors, jig borers and other installations where horizontal and rotary machinery vibrations are present.

Vibration isolation and attendant noise reduction is accomplished through "rubber-in-shear" principle. It consists of a specially designed steel channel floated in rubber between two steel



angles. The correct angularity between steel parts and rubber bonded thereto is said to enable isolator to approximate the "flat" spot on a stress-strain curve of relative slope. Because the spring index (load divided by deflection) is not constant, resonance is said to be avoided.

These isolators, with ample surface mounting areas, are designed to afford uniform deflection and a load range from 600 to 10,000 lb. Finn & Co.

DIESEL MAINTENANCE CUT 50%

Sun Diesel Lubricant Eliminates Hard Carbon, Stops Sludging, Ends Costly Bearing Failures

Troubles began to pile up for a company renting out diesel-powered cranes, air compressors, and heavy-duty earth-moving equipment. Piston rings stuck with hard carbon; sludging resulted in clogged oil pump screens, bearing failures, abnormal cylinder wear. As a result there was frequent necessity for complete engine overhauls. Downtime was excessive.

A Sun Diesel Lubricant proved to be the solution to the difficulties. This "Job Proved" Product, recommended by a Sun Engineer, has been used by this concern for two years now. There have been no stuck rings, no bearing failures traceable to lubrication, no clogged oil pump screens. Cylinder wear is at a minimum. General maintenance costs have been reduced 50 percent. Efficiency is way up—to the profit of both owner and users.

Here is another example of what Sun "Job Proved" lubricants are doing to increase the life and efficiency of machinery. By helping to improve output and quality, and at the same time hold costs down, they can play a large part in making operations show a profit. It will pay you to consider how Sun "Job Proved" Products can be used to advantage by your company. Call your nearest Sun Office for complete information.

SUN OIL COMPANY · *Philadelphia 3, Pa.*

In Canada: Sun Oil Company, Ltd.
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SUN PETROLEUM PRODUCTS

"JOB PROVED" IN EVERY INDUSTRY

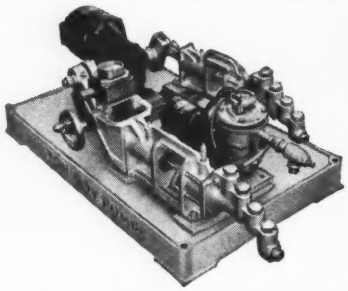
SUNOCO

Mark the numbers of the items you wish to receive on the no obligation, no postage card. Pages 35-36.

18—AUTOMATIC SYSTEM

Is designed for automatic and precise concentration control

The Titronic Pump and Automatic Control System is intended to afford concentration control in caustic or acid baths, even where it is impossible to methods. The system utilizes one side of a duplex controlled volume pump to automatically and continuously titrate a

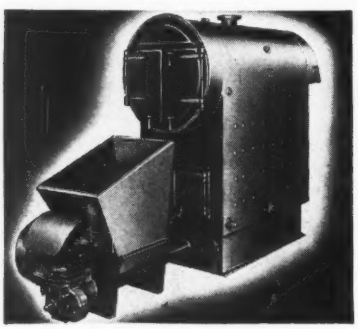


sample from the liquid bath. The other side of the pump meters to the sample, manufacturer explains, in direct ratio and exact proportion, a fixed quantity of titrating system. Milton Roy Co.

19—BOILER-STOKER UNITS

In 10 sizes, with steam radiation capacities of 2,190 to 8,500 sq ft

In these Unitbuilt Combinations the stoker ironwork is factory-installed in the boiler furnace. After the boiler has been set on location, the stoker driving



mechanism is readily connected. This is intended to simplify final assembly work and reduce installation time and expense. Cleanout doors are in front and rear of base. The Brownell Co.

20—PARTS LOOSENER

Is handy device for removing stuck-together parts

The Kroiler dispenses Kroil, company's chemical for loosening stuck parts, and is intended for quick use whenever a frozen bolt, nut or bearing threatens to tie up production. According to manufacturer, the Kroiler shoots the Kroil into places where it can seep into minute spaces to dissolve dried oils, rust and corrosion and supply necessary lubrication to loosen the part without harm to the metal. The Kroiler is $1.50 and Kroil is $3.50 a gal direct from manufacturer. Kano Laboratories.

21—ALARM METER

For flush panel mounting, gives visible and audible warning

This individual alarm meter, Type MC-100, can be mounted on any convenient instrument panel. In case of a trouble signal from a remote location it sounds a horn and flashes a red light. There's a push button to silence the audible alarm and keep the light on steady while trouble is being corrected.

As soon as this is done, the light goes off and the alarm meter relay automatically resets.

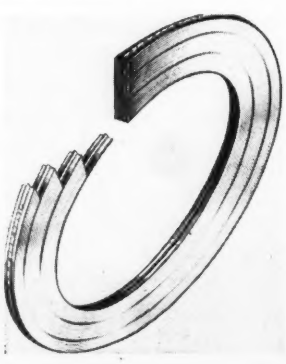
Small in size, the meter is 5½ in. sq, complete in one case. A complete alarm circuit includes the primary alarm switch located on the equipment to be guarded, the horn, and the alarm meter to control and transmit action of alarm switch into visible and audible alarm signal. Standard alarm meter is made for 11 v 60 cycle power, maximum load on primary alarm switch 0.1 amp, maximum current to horn 1.5 amp. The Unit Alarm Co.

22—FLEXIBLE METAL GASKET

Is intended for high pressure and high temperature applications

This all-metal gasket is said to possess the qualities of solid metal without its rigid characteristics. It is reported that in a number of tough applications, it does not take the permanent "set" customarily expected. Even after extended service involving great changes in pressure and temperature, this new all-metal gasket is said to have the resilience required for a tight seal.

Company engineers point out that this flexible gasket is suited to applications where high temperature and the permeability of confined materials limit the use of asbestos or other soft fillers. Flexitallic Gasket Co.



23—BUFFER SOLUTIONS

In re-useable bottles, for calibrating any pH instrument

Nominal pH values of these buffer solutions are 4, 7, and 9; actual, 4.01, 6.86, and 9.16 at 25 C. Solutions are supplied in 1 pt unbreakable, non-contaminating, re-useable polyethylene bottles on which are printed pH-temperature calibrations from 0 to 60 C. Buffers are made, and checked after bottling, to National Bureau of Standards specifications. Leeds & Northrup Co.

24—INSULATION PRODUCTS

For high temperatures include all-purpose block and cement types

A line of recently announced insulation products features a mineral wool all-purpose block for temperatures to 1700 F. Called BL-17, it has a density of 1.67 lb per board ft. It is chemically inert, manufacturer reports, and does not disintegrate or cause rust or corrosion. It will be available in standard sizes.

C-18, a companion product, is an insulating cement composed of mineral wool, long fiber asbestos and an adhesive binder. It is applied like a plastic; 100 lb of it are intended to cover 50-55 board ft. This product is said to be effective to 1800 F, to contain an inhibitor to prevent rust and corrosion, and be reclaimable. Bigelow-Liptak Corp.

25—COMBUSTION CATALYST

For keeping super heaters, burner tips clean, lowering fuel consumption

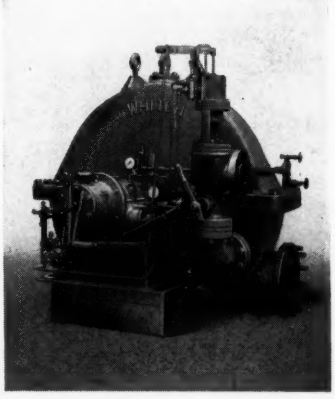
Super 16 is a combustion catalyst intended to eliminate and prevent carbon formations in boilers, sludge in storage tanks, heaters, lines and burners. It is described as non-explosive, non-injurious to metals and containing no ether, naphtha, gasoline or carbon tetrachloride. New Process Chemical Co.

26—HORIZONTAL TURBINE

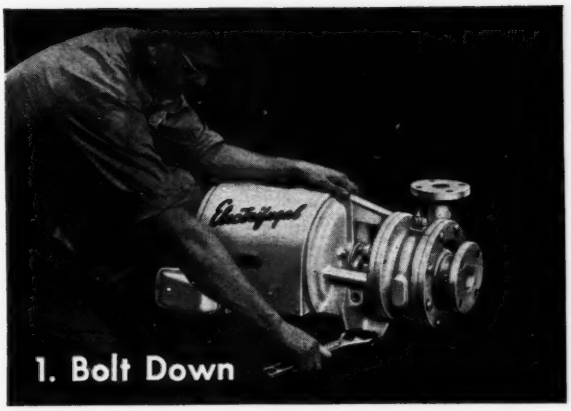
Is large machine of simple design and rugged construction

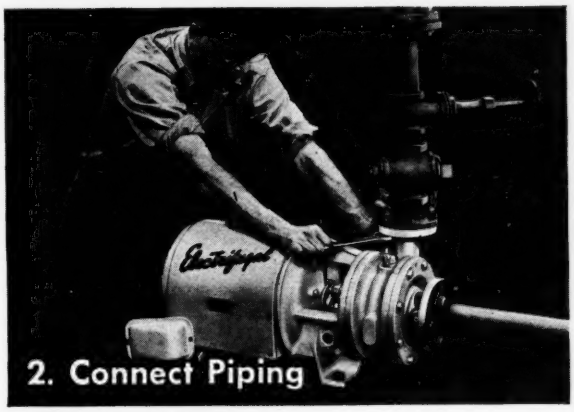
This turbine is designed to develop a 500 bhp at 1750 rpm with 850 to 900 lb initial pressure, 850 F TT and to exhaust into a vacuum of 12 in. or against a 2 psig back pressure. Casing is supported near centerline on pedestal.

The turbine rotor is a solid one-piece wheel of 48 in. dia, the blades being milled around the periphery of a solid steel forging. The turbine is equipped with an oil relay actuated constant speed governor, separate emergency governor of poppet type, gear driven



Electrifugal PUMP





3 Easy Steps

...AND YOU'RE READY TO PUMP

- **No Alignment Problem**
- **No Extra Parts To Buy**

You save hours of expensive installation time with *Electrifugal* pumps because the pump and motor are built as a single complete unit, shipped READY TO RUN. Note that cast iron yoke and bracket for mounting pump are a *single-piece*—eliminating a separate adapter. And because motor and pump are on a *single* shaft, perfect and permanent alignment are assured. No couplings or other extra parts to buy. Maintenance costs less, too, because pump and motor cannot get out of alignment. Packing gland is readily accessible.

The Electrifugal pump, ranging from 10 to 1600 gpm with heads to 525 feet, is just one of many types of pumps built by Allis-Chalmers for industrial uses. You can count on the recommendations of the A-C pump application engineer. For information, see your Allis-Chalmers Authorized Dealer or Sales Office, or write for Bulletin 52B6059E. A-2769

Electrifugal, Texrope and *Vari-Pitch* are Allis-Chalmers trademarks.

Sold . . .
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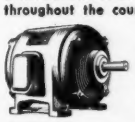

MOTORS — ½ to 25,000 hp and up. All types.

CONTROL — Manual, magnetic and combination starters; push button stations and components for complete control systems.

TEXROPE — Belts in all sizes and sections, standard and Vari-Pitch sheaves, speed changers.

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oil pump to supply oil for governor and turbine bearings, external oil cooler, automatic back pressure trip and standard accessories. Whiton Machine Co.

27—PORTABLE PYROMETER

Is precision-built, multi-circuit instrument for temperature measurement

The Allnor Type 1200 Portable Pyrometers are precision built, multi-circuit, direct-reading instruments designed for accurate and precise temperature measurements at many points in rapid succession. It is recommended for making tests involving the temperature rise of various portions of an electrically operated device, or repetitive tests on a group of devices. Its meter has a scale 6 in. long for reading ease.

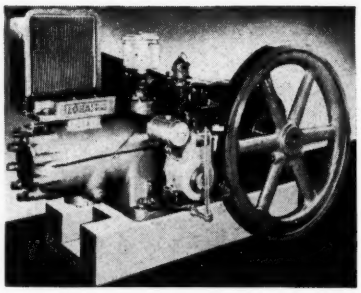
Instruments are made with sapphire bearings, Alnico magnet and bimetallic automatic cold end compensator to compensate for changes in ambient temperature during a test. A mercury in glass thermometer is installed under the scale pan.

Two switch capacities are available, 8 and 17 circuit. Standard switches are designed for "overlapping" contacts, said to be desirable since meter circuit is never opened during switching to eliminate possibility of damaging movement. The 8 circuit switch is also available in a "non-overlapping" design. Housed in walnut case. Prices start at $150. Illinois Testing Laboratories, Inc.

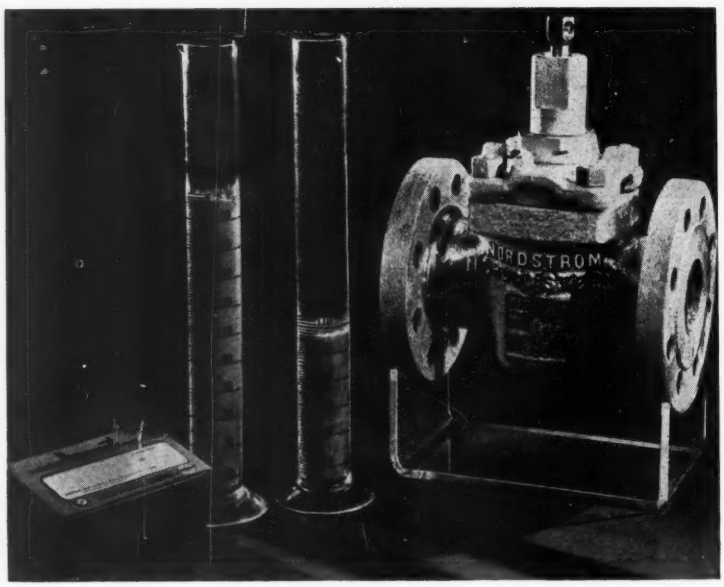
28—HORIZONTAL ENGINES

Two-cycle, single cylinder type, have condenser cooling system

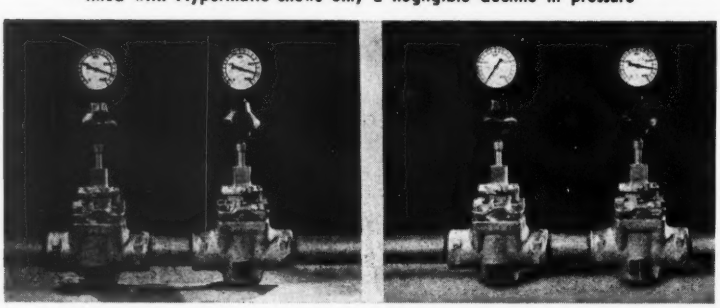
The Lorain Model R and Model A Engines are identical except that the Model R has a 12 in. cylinder bore and 13 in. stroke, and produces 45 bhp at 325 rpm, and the Model A has a 13-in. bore and stroke and produces 55 bhp at the same speed. Both new models have tapered roller bearing crankshafts and auxiliary shafts. Wet-sleeve cylinder liners of alloy cast iron are used to assure long life and easy replacement.



The Model R operates on natural gas fuel only. Model A can be operated as a cold-starting, full Diesel or readily converted to burn natural gas or butane. With condenser-type cooling system, make-up water is said to be negligible. Standard equipment includes Twin Disc Clutch, Pierce Governor, Air Maze oil-bath cleaner, McCord Lubricator and built-in 7½ hp Lorain gasoline starter. Over-all dimensions are: length, 110 in.; width 74 in.; height, 68 in. Shipping weight is 8275 lb. White Roth Machine Corp.



In the photograph above, the left-hand beaker shows volume of Hypermatic lubricant storable in a plug valve; the other beaker shows volume of non-compressible, non-automatic lubricant storable in a valve of the same size. The photographs below illustrate comparative pressure retention. In the first picture are a valve filled with a non-compressible lubricant and one filled with Hypermatic, both pressurized to 350 psi on a test line. The second picture shows that six months later, the pressure on the valve filled with non-compressible lubricant (left) has dropped to 0 psi, while the one filled with Hypermatic shows only a negligible decline in pressure



29—COMPRESSIBLE LUBRICANT

For plug valves, is "energized" for fully automatic action

A compressible lubricant for use in so-called pressurized lubricated valves has been developed by the Nordstrom Valve Div. of Rockwell Mfg. Co., makers of Nordstrom plug valves. As shown by the accompanying illustrations, this lubricant which has been named *Hypermatic* may be compressed to half its volume by putting it under pressure.

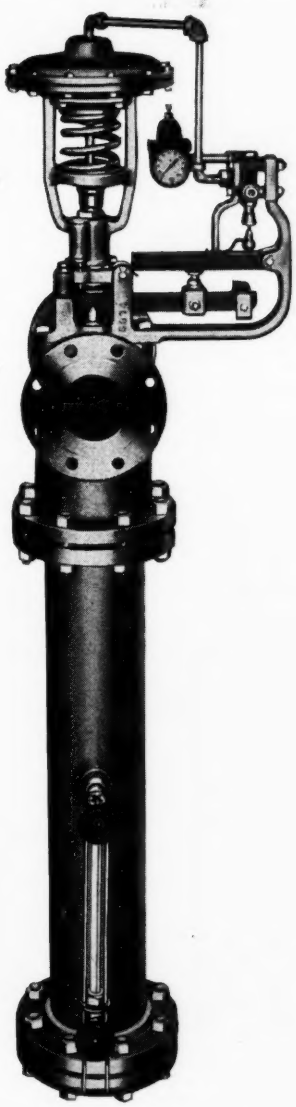
When the pressure is removed, however, the lubricant expands back to its original volume. When compressed the lubricant is in what is called an *energized* state. When in that state it possesses potential energy in the same way that a spring possesses potential energy when it is compressed. Thus, when sealed in a confined space, this new lubricant will effectively fill all voids despite any small leakage that may take place over a period of time. When used in the Nordstrom plug valve it will keep all seating surfaces lubricated.

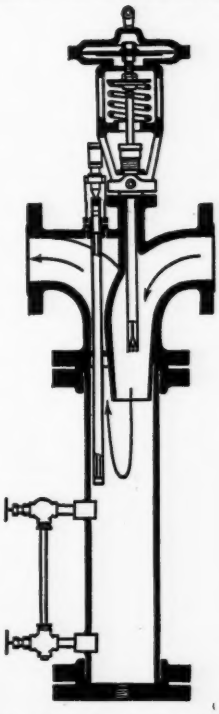
Hypermatic retains its energy, for multiple valve turnings, according to manufacturer, and may be re-energized when necessary by adding more of the same substance to refill valve chambers or by turning lubricating screw. Hypermatic is said to fill lubrication voids until confined pressure drops to a minimum of 50 lb.

Self-acting, this lubricant is held in its energized condition between valve sealing surfaces and ball check valve, manufacturer explains, adding that Hypermatic simply reverts to status of a non-automatic lubricant if valve is neglected over long periods of time.

Advantages stressed for the new lubricant are lower installation and service costs and a higher peak of efficiency. According to manufacturer, the use of Hypermatic is expected to decrease the frequency of valve lubrication, keep the valve in a state of lubrication and maintain it in operable condition.

Self-Contained DESUPERHEATER





Cooling water completely atomized at all rates of flow . . . final steam temperature held closely . . .

Easily installed, the COPES Desuperheater holds the final steam temperature within plus-or-minus 5 degrees F., regardless of changes in initial temperature or rate of flow. Self-contained, it has no outside valve controlling flow. Complete atomization of the cooling water is assured by controlling its flow at the spray nozzle, across which pressure drop is held constant. Intimate contact of water and steam is at point of greatest turbulence in mixing chamber. Write for descriptive Bulletin 405-A.

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1192 GROVE DRIVE, ERIE, PA.
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ENGINEERED BY THE MAKERS OF COPES
FLOWMATIC

COPES furnishes pressure-reducing and desuperheating stations designed and built for the individual installation. COPES also builds-to-measure boiler superheat controls responsive to both steam flow and temperature.

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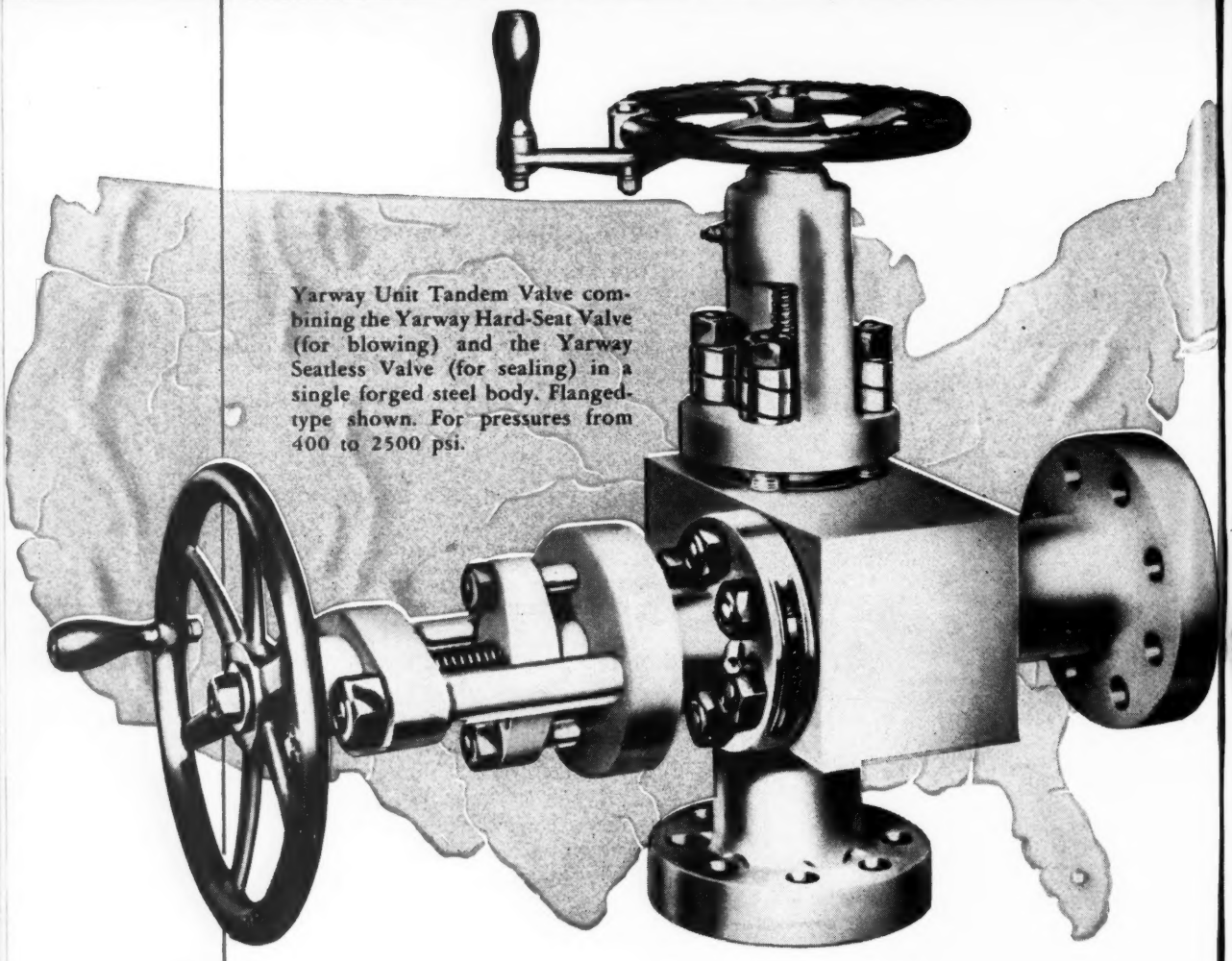
Boiler Feed Water Control . . . Excess or Constant Pressure Control, Steam or Water . . . Liquid Level Control . . . Balanced Valves . . . Desuperheaters . . . Boiler Steam Temperature Control . . . Hi-Low Water Alarms.



Yarway Unit Tandem Valve combining the Yarway Hard-Seat Valve (for blowing) and the Yarway Seatless Valve (for sealing) in a single forged steel body. Flanged-type shown. For pressures from 400 to 2500 psi.

NORTH

WEST EAST

SOUTH

it's YARWAY 4 to 1

From every corner of the country comes the same story—four out of every five high pressure boiler plants are equipped with Yarway Unit Tandem Blow-Off Valves.

Each day's orders add to the evidence. From Ohio . . . 17 new Yarways, making a total of 746 purchased by this large utility over the last 35 years. From California . . . 10 new Yarway Unit Tandems for one company, 9 for another. Texas sends an order of 5 . . . 3 for one new municipal plant, 2 for another. Northern New York wants 7 for new boilers in a well-known utility. And so it goes.

Why this overwhelming preference?

Proved dependable performance, due to outstanding design, sound engineering and careful manufacture . . . plus constant research, leading to mechanical and metallurgical advancements that keep Yarway Valves ahead of changing service requirements.

For latest information on Yarway Unit Tandem Blow-Off Valves, write for Yarway Bulletin B-432.

YARNALL-WARING COMPANY
114 Mermaid Avenue, Philadelphia 18, Pa.

YARWAY BLOW-OFF VALVES

LETTERS TO THE EDITORS

100 IN. HG

IN DAN GUTLEBEN'S answer to Question No. 441 (PG, August, 1949) he mentioned a vacuum of 100 in. mercury. I am interested in knowing how such a vacuum would be produced.

Associated, Calif. R. O. BATHIANY

▶ **Editor's Note—Dan Gutleben, commenting on the problem of pumping molasses at 40 F, said: "If V. L. G. could produce a vacuum of, say, 100 in. of mercury, he might be able to lift the molasses into the pump suction."**

We think this vacuum is in the same class with the 1500-kilometer turbine-generator reported on in *Engineer's Preview*, July issue.

BASIC POWER PLANT FIGURING—MORE ON PRESSURE REDUCING

AS PROMISED ON page 87 October issue, we are presenting here a section of the Mollier Chart on which Mr. Engelman has plotted a series of points to show how dry and saturated steam at high pressure would expand through a reducing valve. Above 450 psi (which is not high pressure any more) this in most cases would result in final steam containing moisture. It must be remembered, however, that in practice, the cases when we are dealing with dry and saturated steam at 900 or 1250 psi are not very common.

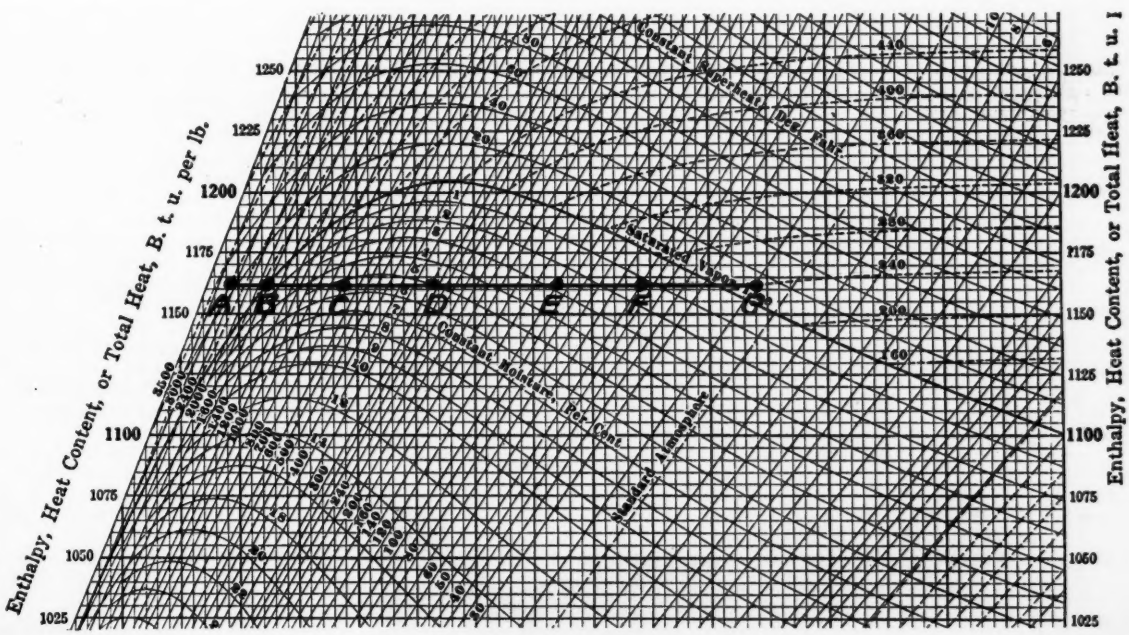
We are also deeply indebted to Jesse L. Erisman for a detailed and erudite discussion but without complicated mathematics, of the various relations in the higher pressure parts of the Mollier Chart. Mr. Erisman points out that it is important, especially for young engineers, to know these general principles in case questions on them are given in examinations. If you want this discussion, the editors will send you a copy on request.

In extremely rare cases, says Mr. Engelman, the reduction of steam pressure through a reducing valve might place the steam in four different successive conditions: a. superheated; b. dry saturated; c. wet, (moist); d. superheated.

Assume that steam at 2600 psia and 702 F total temperature is passing through 6 reducing valves in an infinitesimal time to a final pressure of 20 psia. What would be the conditions of the steam with the following pressures in each step: 2,600 to 1,600 to 700 to 300 to 100 to 50 to 20 psia (final). The chart shows them and they are tabulated below.

In the initial and final condition the steam was superheated, in the 1st reduction to 1600 psia it was dry saturated steam (100 per cent quality), but from the 2nd to the 5th reductions the steam contained moisture. From Keenan and Keyes, Properties of Steam, table 2, page 38, the maximum enthalpy (Btu) for dry saturated steam is at 450 psia. At higher pressures under these conditions, the enthalpy decreases. For further explanation see POWER GENERATION, March, 1949, page 95, Table 4, also the July, 1949 issue, page 60 and 61.

	Press. psia	Moist per cent	Total Temp. TT	Super-heat deg F	Btu per Pound	Entropy
Initial Condition A	2,600	none	702	28	1162	1.292
1st. reduction to B	1,600	dry	605	none	1162	1.325
2nd. reduction to C	700	5.5	503	none	1162	1.389
3rd. reduction to D	300	5.0	417	none	1162	1.465
4th. reduction to E	100	2.8	328	none	1162	1.570
5th. reduction to F	50	1.33	281	none	1162	1.643
6th. reduction to G	20	none	240	12	1162	1.740



Portion of Mollier Chart

THIS MONTH'S *Power Generation* FEATURE

This is a description of the combined highest pressure and highest temperature turbine generating unit in the world—the new Unit 5 at Twin Branch Station of the American Gas and Electric Service Corp. This unit, which is rated at 137,500 kw, is designed for operation at 2000 psi, 1050 F. While a pressure of 2000 psi has been used before and steam temperatures of 1050 degrees are in use in several plants, this is the first time these pressures and temperatures are used together. This new unit is expected to set a new record for efficiency of steam electric generation with a heat rate of better than 9200 Btu per kilowatt-hour

Twin Branch—A Study of Progress in Power Generation

Review of development on American Gas & Electric system . . . Development at Twin Branch . . . Unit 5 — 2000 psi, 1050 F . . . Unit 5 Boilers . . . Steam Attemperators, Economizers and Air Preheaters . . . Turbines . . . High temperature piping . . . Condenser and feed water heaters . . . Electrical Features . . . Control . . . Future Developments

By
S. N. FIALA, Mechanical Engineer;
H. A. KAMMER, Chief, Design and Construction;
F. A. LANE, Electrical Engineer,
American Gas and Electric Service Corporation

IN 1937, in a discussion of the aims of the new 2400 psi, 940 F Twin Branch Unit 3, Philip Sporn, then vice president and chief engineer of the American Gas and Electric Service Corp., stated that this unit had introduced "a period of temporary stability on the pressure end of power plant development . . . leaving the period of the next decade or two to the development of higher temperatures."[1] In August of this year, 12 years later, Unit 5 at the Twin Branch plant of the Indiana & Michigan Electric Co. was first placed in service adding 137,500 kw to the capability of the Twin Branch plant and utilizing steam at 2000 lb pressure and 1050 F, with reheat to 1000 F. Thus Mr. Sporn's prophecy is becoming a realization. This new unit is expected to set a new record for efficiency of steam-electric generation with a heat rate of better than 9200 Btu per kilowatt-hour.

The Indiana & Michigan division of the Central System of the American Gas and Electric Co. serves a combined industrial and residential load through the upper half of Indiana and through the southwest section of Michigan (Fig. 2). Its present peak load is approximately 445,000 kw and it is experiencing a healthy growth. This load is furnished from the Twin Branch plant, from secondary steam and hydro installations and by purchase from interconnected systems both within and without the company affiliated groups.

Soon after the war, the rapid growth of load throughout the entire Central System as well as in Indiana and Michigan, once again pointed to the need for capacity additions in the western end of the Central System, at Twin Branch. A vital factor that has been involved in every Twin Branch extension is the location of the plant at the most

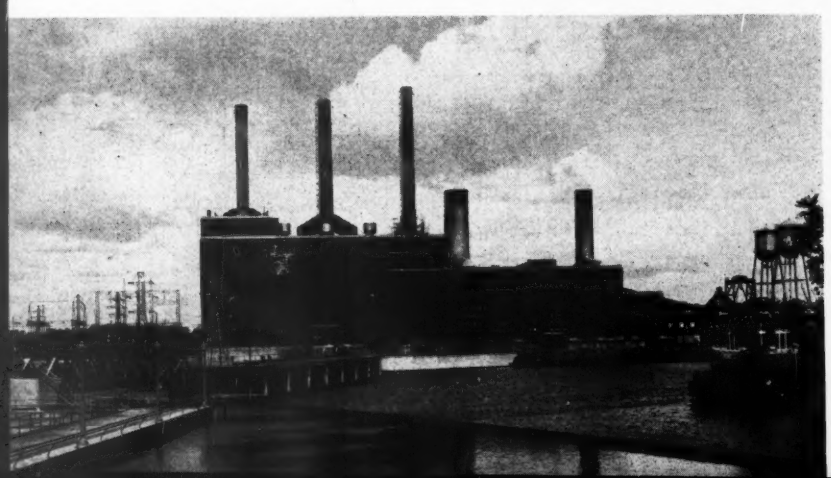


Fig. 1. Twin Branch Station of the American Gas & Electric Service Corp. This plant has a generating capability of 380,500 kw

1 "2400 Pounds—A New Power Milestone" —Philip Sporn, *Electrical World*, October 9, 1937.

expensive fuel point on the Central System. With the magnitude of load experienced in the Indiana & Michigan division and in the rest of the Central System, and with present limitations on the transmission of large quantities of electrical energy over the distances involved, it has been imperative that all Twin Branch installations be of the highest commercially feasible thermal efficiency. Such thinking lay behind the decision to proceed with the high-temperature high-pressure cycle developed in Unit 5, as it did in all previous Twin Branch installations.

Unit 5 probably represents the last increment of capacity permitted by circulating water limitations at the Twin Branch site. Additional capacity is being developed at the Tanner's Creek site on the Ohio River in southeastern Indiana, where a 137,500 kw unit similar to Unit 5 is under construction. Further capacity at Twin Branch may be developed in the future by replacing one or both of the older units with larger high-pressure, high-temperature units with circulating water requirements no greater than the requirements of the older units.

Before proceeding with a description of the new unit, it will be of interest to review the successive additions to the original Twin Branch site.

Original Twin Branch Installation—Units 1 & 2

The installation of Units 1 and 2 in the Twin Branch plant in 1925 aroused considerable interest in engineering circles for high steam pressure and temperature, use of reheated steam, turbine bleeding for regenerative feedwater heating and economical performance. These units were rated at 40,000 kw utilizing steam at 600 psi, 725 F with reheat at 725 F between the seventh and eighth stages of the single cylinder, bleeder-type turbines.

Elsewhere in the United States, 400 psi was the top operating pressure, except for a 2500 kw 1200 psi 700 F topping unit then being pioneered by the Boston Edison Co. Only half a dozen units were operated with steam closely approaching or exceeding 700 F, due to metallurgical limitations. Reheating of steam for better economy and bleeding of turbines for regenerative feedwater heating were then in a pioneering stage.

Units 1 and 2 produced power at rated load at a heat rate of 14,000 Btu per net kwh. In 1925 steam electric performance better than 15,500 Btu per kwh was rare indeed throughout the country. These units were considered large when installed, the largest single shaft unit in operation at that time being 50,000 kw. Steaming capacities of the three standard and one reheat boiler which served each unit were then high and were not greatly exceeded until 1927.

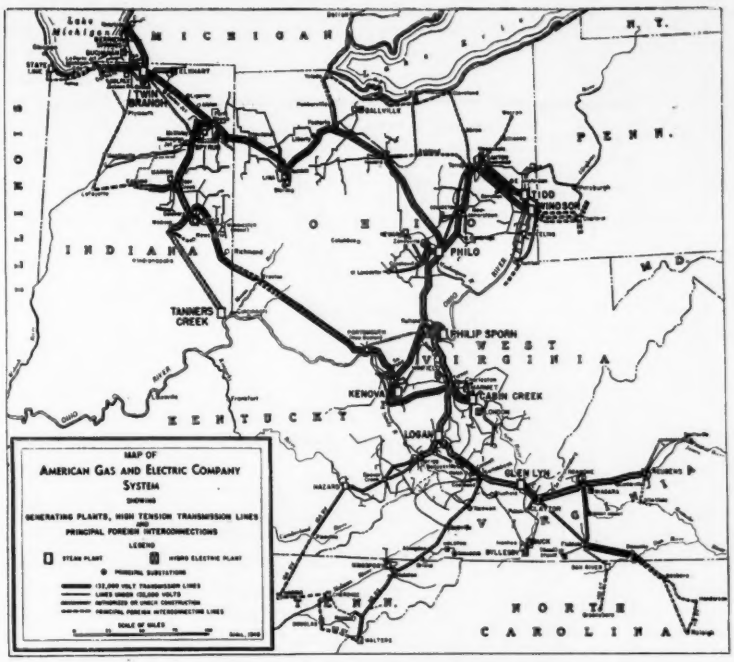


Fig. 2. Twin Branch is part of this 7-state interconnected system
The system now has close to 2,000,000 kw generating capacity, but 687,500 kw more is under construction at two new steam power plants—Philip Sporn Plant (4 authorized units totaling 550,000 kw net capability) and Tanner's Creek Plant (one authorized unit of 137,500 kw). Units will be placed in service at Philip Sporn Plant during this year, 1950 and 1952; Tanner's Creek in 1951.
Besides being completely integrated internally, the system is interconnected along its margins with outside utilities at 32 points. Consequently the entire arrangement permits mutual assistance and assures the maximum economies and reliability obtainable with interconnected and coordinated operation

An unusual feature of this plant was its location at a hydro site on the St. Joseph River. The location of the condenser circulating water intake below the dam eliminated completely the need for circulating water pumps. Circulating water requirements have been met without the use of circulating pumps in Units 3 and 4, and to date no circulating pumps have been provided for Unit 5.

Like the Philo plant, whose first two units were essentially duplicated, the Twin Branch installation was designed for base load operation, and delivered its power directly to an integrated electrical transmission and distribution system.

Second Major Development at Twin Branch—Unit 3

By 1937, when the growth of electric demand showed signs of recovery from the doldrums of the depression, it became evident that additional capacity must again be added to the western end of the Central System. The existing Twin Branch plant was the logical site for further development. Original plans for Twin Branch expansion had contemplated the eventual installation of four additional units similar to the first two. So far had the art of steam-electric generation progressed in the 12 year interval, however, that duplication of the original unit could not even remotely be contemplated. Instead, the decision was made to push out beyond the frontier of generating practice into a new pressure region—2400 lb—which appeared to be commercially feasible, and which represented a major forward step in power plant practice. This pressure is still the highest applied in a utility plant in this country. Steam temperature was fixed at 940 F with 900 F reheat, the highest temperature permitted by existing high temperature metallurgical technology. A single powdered-coal-fired boiler supplies 570,000 lb of steam per hr to the high pressure turbine, and reheats 460,000 lb per hr for delivery to the low pressure turbine, to develop a total net output of 72,000 kw at a heat rate of slightly under 10,300 Btu per net kwh.

Experience with that pioneer in the 2500 psi class was fully related in a paper before the ASME[2], which revealed that the performance of the unit ever since it went into service has justified its design and proved its economy.

A Wartime Development—Unit 4

Further wartime electric power demand on the entire Central System soon pointed to the need for another major extension of the Twin Branch plant. Wartime restrictions on materials, and the urgent need for additional capacity suggested

[2] ASME—Paper of December 3, 1943, Philip Sporn and E. G. Bailey, "Operating History of 2500 psi Twin Branch Plant"; also *Electrical World*—issues of October 9, 1937 and October 18, 1941.

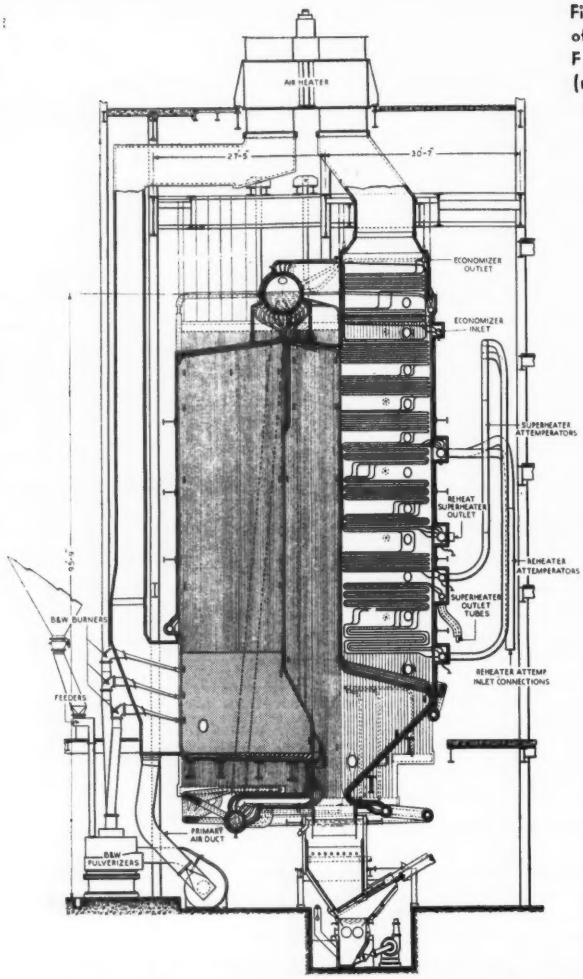


Fig. 3. Cross section of the 2000 psi, 1050 F (initial) 1000 F (reheat) boiler serving Unit No. 5

consideration of a more conventional installation than Unit 3. A unit similar to Units 4 and 5 of the Philo plant (Ohio) was selected and placed in service early in 1944. Information about this unit has not been published until now.

Unit 4, a cross-compound installation, rated at 85,000 kw, has a net output capability of 95,000 kw. Steam is supplied by two Babcock and Wilcox open-pass boilers, each with a rated capacity of 450,000 lb of steam per hr at 1375 psi and 950 F. The higher temperature and better boiler efficiency of Unit 4 provides a heat rate of 10,750 Btu per kwh, somewhat above that of Unit 3. Five stage regenerative heating is provided by steam bled from these three stages of the 1800 rpm low pressure turbine and two stages of the 3600 rpm high pressure turbine.

Boilers for Unit 4

Each boiler is equipped with six multi-tip intertube pulverized-coal burners mounted on the roof of the primary furnace. Fuel-air mixture from the burners is discharged down into the primary furnace, where combustion takes place. The combustion gases then flow across the furnace outlet screen, up the first open pass, across the upper screen, down the second open pass, across the convection pass inlet screen, up through the convection pass and thence to the Ljungstrom air heaters and dust collector type induced draft fans.

Steam leaving the drum passes through the primary superheater, the multiple nozzle spray attemperator and secondary superheater, in that order. Steam temperature is controlled at 950 F over a load range of 340,000 to 450,000 lb per hr by regulating the amount of feedwater sprayed into the steam through one or more of the five atomizing spray nozzles of the attemperator. This interstage steam temperature control using a spray type attemperator was first developed on Unit 3 at Twin Branch and has today become a well established means of controlling superheat in large high-pressure boilers.

Draft for each boiler is furnished by a single forced draft fan and two induced draft fans, all motor-driven. Pulverized coal is supplied by three motor-driven pulverizers each capable of grinding 10 tons per hour. Molten slag from the primary furnace and first open pass flows into a single water-filled ash-hopper, from which the disintegrated slag and ash are sluiced to an ash pump suction pit for disposal.

It was originally intended that these boilers would be exact duplicates of the four boilers installed in 1941 for Units 4 and 5 at Philo. Several design changes were made, however, principally to reduce furnace wall and tube maintenance, to reduce excessive slagging, and to conserve high alloy steels formerly used in supehheater and economizer locations.

These boilers are somewhat unusual in that a continuous rating of 450,000 lb of steam per hr is obtainable from a boiler only 16.6 ft wide. Heat liberation rate in the primary furnace is 91,000 Btu per cu ft at full load, and gas velocity in the open passes is approximately 60 mph. Overall boiler efficiency is slightly over 85 per cent at full load.

Turbines and Generators

The 14 stage high-pressure turbine 3600 rpm is rated at 45,600 kw, and is directly connected to its hydrogen-cooled generator. Steam from the boiler passes through an emergency stop valve to two control valve chests mounted on the upper and lower halves of the high-pressure shell. From here, ten control valves distribute steam to the first stage nozzles. The high-pressure turbine exhausts at 120 psi, 750 F to a 12 stage 1800 rpm low pressure turbine rated at 39,400 kw. This turbine also has its own stop valve and control valve for independent operation. Stellite strips are mounted on the last row of turbine buckets to prevent erosion by wet exhaust steam.

Quick-closing intercept valves are mounted between the two turbines, and are shut by the low pressure turbine governor should that turbine reach an overspeed of 2 per cent. Simultaneously, the high pressure control valves are shut, and if speed fails to drop rapidly enough, the low pressure emergency governor closes the high-pressure stop valve.

The turbine control system operates hydraulically at 250 lb oil pressure furnished by two main oil pumps located in the main oil tank, driven by long shafts geared to the main turbine shaft. Two motor-driven auxiliary oil pumps, connected to both a-c and d-c sources are started when hydraulic pressure fails, and also when starting and stopping the main units. Bearing oil at 25 psi is supplied to the high pressure turbine from a separate section of the main oil pumps, and an additional supply of bearing oil is available through a reducing valve. The low pressure turbine has its own bearing and hydraulic oil pumps and is operated as a separate unit with a common oil supply between the two tanks.

The low pressure unit can be operated as a single unit when the

high pressure turbine is out of service. Steam can be supplied through a reducing station from either a 1300 psi steam line from the high-pressure boilers, or a 600 psi line from the old boilers. The steam pressure is reduced to 120 psi and desuperheated, if necessary, to 750 F. On separate operation, the operating governor operates the low-pressure control valve and holds the speed of the turbine at 1800 rpm.

Unit 5—2000 Psi, 1050 F

Shortly after the end of the war, it became evident that considerable additional capacity would be needed to meet a rapidly growing demand for electric power on the Central System. Wartime restrictions on materials, particularly high alloy steels suitable for high temperature work, had been lifted. The completion of Unit 2 at the Tidd Plant in September, 1948 would place a block of 110,000 kw on the line, and provide a breathing spell after the tight capacity situation of 1947-48. There was now nothing to prevent the consideration of another major advance in steam-electric generation.

Accordingly, American Gas and Electric Service Corp. engineers proceeded with the design of the 137,500 kw, 2000 psi, 1050 F, 1000 F, reheat cycle, the most efficient large size commercially practical steam-electric generating unit currently feasible. Four very similar units are being installed on the American Gas and Electric System at the Philip Sporn Plant jointly owned by the Appalachian Electric Power Co. and The Ohio Power Co., and another such unit will soon be in operation at the Tanners Creek Plant of the Indiana & Michigan Electric Co. The principle features of the first two Philip Sporn units have been described elsewhere.[a]

Any distinction to which the new Twin Branch Unit 5 may be entitled should rest not so much on the steam temperatures or the pressures used, but rather on the use of the highest combination of temperature and pressure yet applied commercially in American power plants.

The heat cycle of Unit 5 is presented in Fig. 5. Heat balance calculations indicate that the combination in Unit 5 of a 12 per cent higher steam temperature, but 13 per cent lower pressure than used in Unit 3 will give a better heat rate, 9,170 Btu per kwh, an improvement of 11 per cent over Unit 3.

[a] Philip Sporn, "The 2000-psi, 1050F, and 1000F Reheat Cycle at the Philip Sporn and Twin Branch Steam-Electric Stations Transactions of the ASME for May, 1948 pgs 287-294.

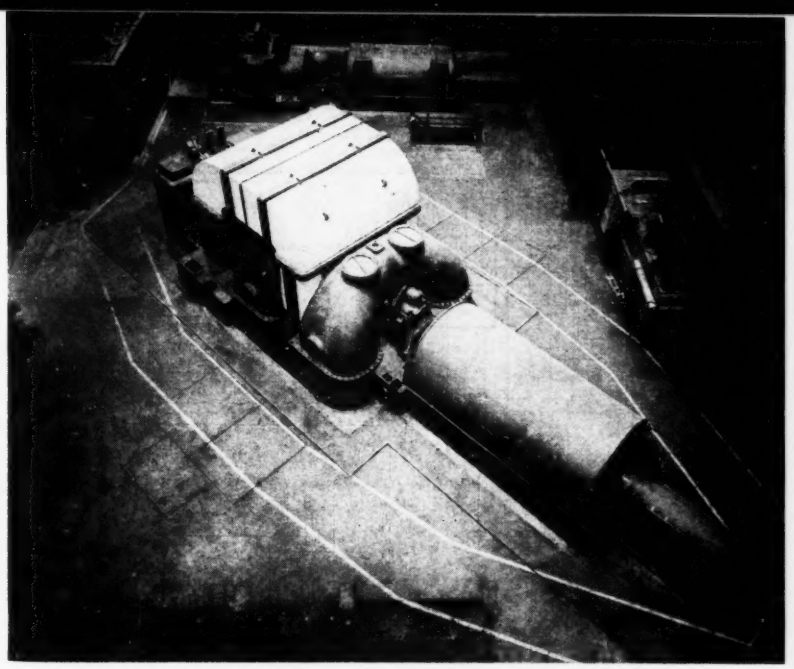


Fig. 4. Unit No. 5. The diagonal arrangement was necessary because of space limitations. The high pressure element is shown in the background

There was no question in the minds of the designers that the regenerative reheat cycle offered the best thermal economy in this case. Comparative cost estimates of reheat versus non-reheat showed a balance in favor of reheat, roughly a 5 per cent better heat rate with about 2 per cent higher first cost. The collective experience at other high-pressure plants designed by American Gas and Electric Service Corp. including Windsor (W. Va.), Philo (Ohio), Cabin Creek (W. Va.), Deepwater (N. J.), Logan (W. Va.), and Tidd (Ohio) was brought to bear in the design of Unit 5 at Twin Branch.

The high steam temperatures used were made possible by metallurgical improvements since Unit 3 was designed, principally the development of high temperature alloys containing high percentages of chromium, nickel, molybdenum, vanadium, tungsten and other components.

2000 Psi, 1050 F, High-Output Boiler

All steam for the new Twin Branch unit is supplied by a single 2-pass radiant-type Babcock and Wilcox boiler fired with pulverized coal through horizontally inclined burners. Maximum steaming capacity is 930,000 lb per hr when delivering 2000 psi, 1050 F steam to the high pressure turbine. Some 840,000 lb of steam at 420 psi is returned to the boiler and reheated to 1000 F for delivery to the low pressure turbine. The total heat input to produce 137,500 kw net generation is slightly over 1.35 billion Btu per hr.

The two drum radiant water wall boiler was designed with utmost simplicity of circulation circuits in mind, and embodied much of the experience gained with the 2400 psi boiler of Unit 3. (See boiler cross-section, Fig. 1.) Steam generating water wall tubes completely line the combustion chamber. Wall tubes in the lower quarter of the combustion chamber are studded and covered with chrome ore, protecting the tubes from molten slag and from impinging flames from the ten horizontally inclined pulverized fuel burners. The four furnace walls are composed of 3 in. OD tubes spaced on 3 in. centers, forming a continuous water cooled steel-jacket which absorbs furnace heat chiefly by direct radiation and generates the greater portion of the total steam delivered by the boiler. (See accompanying table for relative proportions of heat absorbing surfaces.)

Molten ash is continuously drained from the bottom of the combustion chamber over a condensate cooled dam which maintains a thin pool of slag on the furnace hearth. The molten ash discharges into a submerged slag hopper where the slag is chilled and partly disintegrated. This slag and fly ash collected from the bottoms of the first and second

Proportions of Heat-Absorbing Surfaces in Twin Branch Unit 5 Boiler

Surface	Sq Ft	Per Cent Total: Pressure Parts	Per Cent Total: Including Air Preheater
Steam-Generating Water Tubes	23,557	17.5	5.7
Superheating Surfaces	62,770	46.5	15.1
Steam Reheating Surface	30,200	22.4	7.3
Economizer Surface	18,300	13.6	4.3
Total Pressure Parts	134,827	100.	
Air Preheater	281,400		67.6
Total Including Preheater	416,227		100.

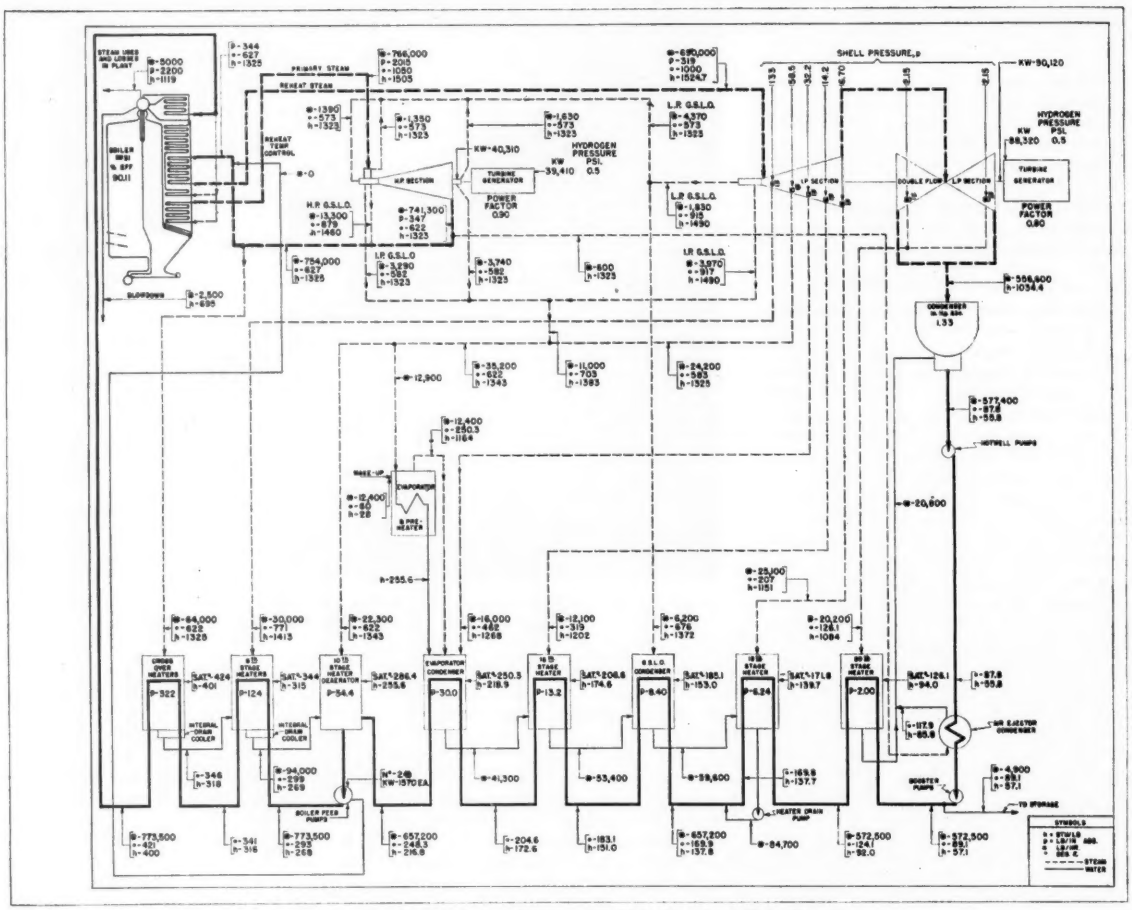


Fig. 5. The heat balance diagram for Unit No. 5 at Twin Branch

boiler passes is crushed and pumped to a disposal area outside the plant.

Five ball-ring coal pulverizers serve this boiler. Four of the pulverizers will carry the boiler's rated load. The fifth unit will serve as a spare, and will aid in handling large loads when only extremely low-grade coal is available.

To assure proper natural circulation of the boiler water, a vital factor in high pressure operation, corresponding ends of the upper steam drum and the lower water drum are connected by 24½ in. downcomers outside the boiler casing, which are considered adequate on the basis of experience with Unit 3. The wall tubes discharge their steam-water mixture into the steam drum through cyclone type separators, which release the steam to the upper part of the drum and deliver the water to the lower part.

The steam drum is 54 ft long, 6½ ft outside diameter, 6⅜ in. thick, and weighs 275,000 lb. It and the entire boiler are suspended from girders nearly 113 ft above the ash basement floor. At each end of the drum are connections for four safety valves.

Steam leaving the drum passes through the primary superheater, external spray-type attemperators (two in parallel) and the secondary superheater to the high-pressure turbine in the order named.

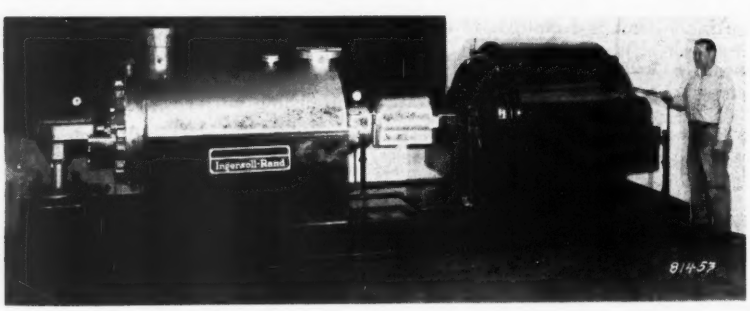


Fig. 6. One of the three 1100 gpm boiler feed pumps

Steam Attemperators, Economizers and Air Preheaters

The temperature of the steam delivered to the high-pressure turbine is automatically maintained at 1050 F above 80 per cent of rated load by regulating the amount of feed water sprayed into the steam between the primary and secondary superheater elements. Reheat steam temperature is maintained at 1000 F by similar means. No dampers are used to bypass furnace gases past the superheater for steam temperature control, reducing maintenance problems, and permitting full utilization of all absorbing surface at all loads.

Low load operation is facilitated by provision for recirculation of a portion of the gases leaving the economizer back through the combustion chamber to help maintain superheat temperature. Flue gases leaving the economizer pass through two Ljungstrom rotating regenerative air preheaters on their way to the multiple-cyclone dust collectors and stack. The preheaters reclaim about ⅔ of the heat in the gases leaving the economizer and heat the air fed to the pulverizers and burners to 550 F. The temperature of the

stack exit gases is only 235 F at full load, illustrating the expected boiler efficiency of over 90 per cent at all operating loads.

Another outstanding feature will be the attempt to operate without induced-draft fans. To this end, the entire casing has been made tight for a furnace pressure of 15 in. of water. However, induced-draft fans have been installed in the event that they are needed.

Turbines

The cross-compound turbine (Fig. 4) is a new combination of high-pressure and low-pressure turbines. The 3600 rpm high pressure element has a rating of 35,000 kw. The two emergency stop valves as well as the turbine inner shell will be chrome-nickel-molybdenum steel, columbium stabilized. The turbine outer shell will be molybdenum-vanadium steel.

The 1800 rpm low-pressure element has an intermediate-pressure turbine in tandem with a double-flow low-pressure section. The whole is rated at 95,000 kw. The intermediate-pressure section receives steam from the reheater at 385 psi, 1000 F and exhausts at about 8 psia to the double flow low-pressure section. Its high temperature parts will be of molybdenum-vanadium steel.

Extreme temperatures in the low-pressure unit exhaust while starting or dumping load are avoided by arrangements for injecting condensate into the crossover between the two turbine elements. Overspeed of the low-pressure element is avoided by intercept valves on the intermediate-pressure turbine inlet which act as control and stop valves should the speed increase 5 per cent above synchronism. Stage pressure gages guide correction of stage pressure differentials. Additional gages have been provided in the stages which experience has shown are within the range of silica deposits.

Turbine bearing oil during normal operation is supplied by an oil turbine-driven lubricating oil pump. High pressure oil for the oil turbine is supplied by a centrifugal oil pump driven by the steam turbine shaft. Auxiliary oil pumps are connected to a-c and d-c motors.

High Temperature Piping

Space limitations between the boiler superheater outlet and the turbine prompted the selection of a unique arrangement of main steam piping. Two superheater outlet headers deliver steam to 18 5½ in. OD, 1 in. wall, chrome-molybdenum tubes, each about 120 ft long. Hairpin bends in the tubes provide sufficient flexibility to reduce thermal expansion stresses on the boiler, turbine and piping to low limits. One, or even two large diameter pipes would have been so stiff as to introduce high terminal expansion stresses on the boiler, turbine and on the piping itself.

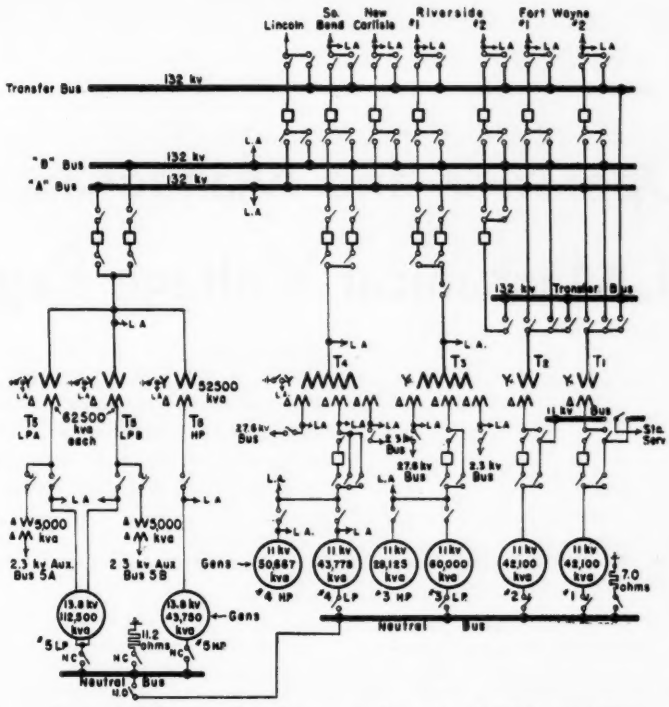


Fig. 7. Simplified one-line diagram of the major electrical connections

The 18 flexible tubes deliver steam from the superheater outlet headers to the main steam lead. This lead is actually a forged gun barrel over 40 ft long, 18 in. in diameter, with a wall over 3½ in. thick, and like the 5 in. tubes, is made of chrome-molybdenum steel. Four 6 in. stainless steel leads deliver steam from two emergency stop valves to the turbine control valve steam chest.

In the main steam line are located two welded joints between chrome-moly and 18-8 stainless steel pipe. Since the co-efficient of expansion of the 18-8 stainless is approximately 50 per cent greater than that of the chrome-moly steel, there was some concern about the safety of a heavy wall weld made between the two materials. After considerable study, a suitable welding procedure was developed and the joints butt-welded, using backing rings, at the General Electric shops. As an added precaution, a test bottle made of capped lengths of chrome-moly and 18-8 stainless welded together has been mounted at the joint and piped to permit circulation of 2000 psi, 1050 F steam for cycling and other tests without disturbing the main joints. A capped tube extending to the center of the test bottle will permit gamma-ray inspection of the joint whenever desired.

Condenser and Feedwater Heaters

A single-pass divided-water-box condenser with a surface area of 65,000 sq ft receives the steam exhausted from the low-pressure turbine. A total of 9874 arsenical copper tubes are supplied with 100,000 gpm of circulating water to maintain an average annual absolute pressure at full load of 1½ in. of mercury, removing some 630,500,000 Btu per hr from the exhaust steam. Removal of air from the condensers is accomplished by a 2-stage triple-element steam-jet air ejector with inter and after condensers, with high-capacity priming jets installed for starting.

Heating of condensate for boiler feed is accomplished by 8 heaters in series, as shown in the heat balance diagram (Fig. 5). Positive pressure deaeration is provided by the 10th stage deaerating heater, insuring delivery of oxygen free feedwater to the boiler.

The three main 1100 gpm boiler-feed pumps (Fig. 6) are designed for a delivery pressure of 2500 psi. They are motor-driven 11-stage centrifugal pumps with forged steel barrel-type casings and alloy steel rotor assemblies. Their induction motors are rated at 2000 hp 2300 v, at 3570 rpm.

Electrical Features

Extreme simplicity is the feature of the whole electrical design (See one-line diagram Fig. 7). Both the 3600 rpm and 1800 rpm, 13,200-v hydrogen-cooled generators are connected directly, without intervening oil circuit breakers to their 3-phase transformers, which step up the voltage to 132,000 for transmission. The low-pressure machine, like several other System 1800 rpm units, is provided with two electrically independent windings, each of which is connected to its individual trans-

(Continued on page 106)

Operation and Maintenance of Mechanical Voltage Regulators

This is a practical explanation of the principles underlying the modern mechanical voltage regulator for a-c generators together with a discussion of its operating characteristics. It gives all the information which the operator needs to know in the care and maintenance of these important devices. A brief history and description of the earlier Tirrill regulator also is given

By **W. H. TURNER** Control Engineering Division, General Electric Company, Schenectady, N. Y.

ALL ALTERNATING-CURRENT GENERATORS of standard design have an inherent voltage drop with each increase in load; consequently, automatic generator-voltage regulators are a necessity on every electric generating system.

Good voltage regulation assures proper operation of lights, radios, appliances, motors, and heating devices. Voltages higher than normal result in increased transformer losses and lamp renewals, while voltages lower than normal result in revenue losses and dissatisfied customers. With a good voltage-regulation system, stability is increased and the station operators are relieved from constantly watching the generator voltmeters.

On the great majority of machines, accurately regulated alternating-current voltage is obtained by the use of a mechanical regulator operating in the field of the associated exciter, which is usually direct-connected but may be belt-driven or motor-driven.

With the introduction of the first Edison bipolar generator, the need for automatic voltage regulation was recognized. As a matter of fact, one of the earliest mechanical generator-voltage regulators was designed in 1882 by Thomas A. Edison. It consisted of a single set of contacts which short circuited across a regulating resistance in the excitation field. This model was subject to hunting difficulties.

About 1902, Allen A. Tirrill introduced his now well-known vibrating voltage regulator. This unit had one or more relay contacts (connected across the exciter-field rheostat) controlled by a pair of cooperating main contacts; one of the contacts was controlled by the characteristics of the exciter voltage, the other contact by the value of a-c generator voltage. Some of these vibrating regulators are still in successful operation. However, many of these regulators have been replaced by modern, simple, non-vibrating, "direct-acting" type units and, for large central-station generators having both main exciters and pilot exciters, by the "indirect-acting" type. For the latter type, normal control is obtained by simply notching a motor-operated field rheostat located in the main exciter field.

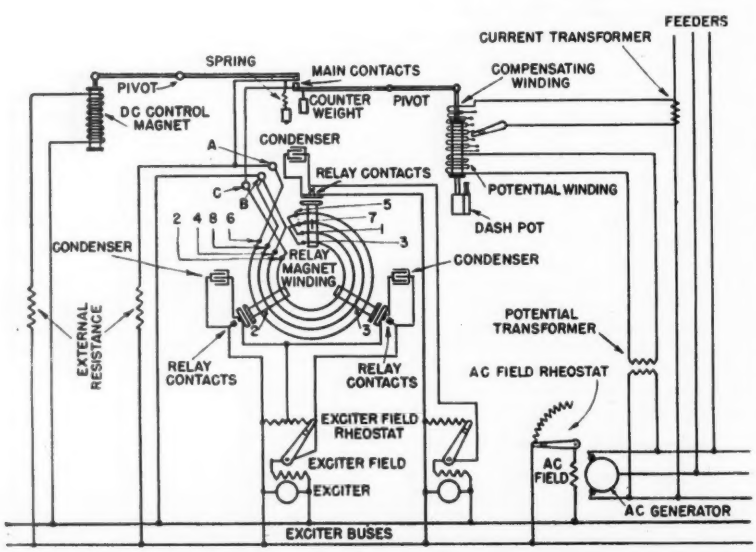


Fig. 1. Wiring diagram of the vibrating type voltage regulator

Vibrating Generator—Voltage Regulator

With the vibrating generator-voltage regulators (Fig. 1), the voltage of the alternator is held practically constant by the automatic opening and closing of a short circuit across the exciter-field rheostat, thus varying the exciter voltage to satisfy the demands of the a-c generator. The generator-field rheostat is usually left in the minimum-resistance position, thus eliminating this heating loss and allowing the exciter to operate at lower voltages. The exciter voltage is reduced to the value actually required across the field of the generator.

A standard vibrating voltage regulator is made up of two parts: a direct-current system which maintains an average exciter voltage by the rapid shorting of the exciter-field rheostat, and the alternating-current system which regulates the value of exciter voltage to be held by the d-c system.

The main direct-current control magnet, with its limiting resistor, is connected across the exciter voltage. This magnet is provided with

two cores; the lower core is fixed, while the upper core is movable. The movable core is attached to a pivoted lever at the opposite end of which is a main contact. A differentially wound relay magnet with its resistor is connected to the exciter voltage. One winding is permanently energized, while the other winding is energized or de-energized by the floating main contacts. When the main contacts are closed, the two windings neutralize each other, allowing the relay springs to close the relay contacts. When the main contacts are open, only one relay winding is energized, and the pull caused by this winding overpowers the pull of the relay springs and opens the relay contacts. An ordinary rate is 200 vibrations per minute.

The potential winding of the main alternating-current control magnet, with its external resistor, is connected across the generator potential through a potential transformer. The magnet is a solenoid type having a laminated core which is attracted up by the magnetizing force. The pull of the magnet is assisted by a counterweight. Adding weight to the counterweight causes the regulator to hold a lower regulated voltage, while removing weight increases the value of regulated voltage. The a-c solenoid core, due to changes in generator load, travels slightly down or up demanding an increase or decrease in exciter voltage to hold the desired a-c generator voltage. Oscillation or hunting of the a-c core is prevented by an oil dashpot located toward the bottom of the a-c core stem.

When one vibrating regulator controls two or more generators in parallel and the characteristics of the generators are different, it is necessary to lower the resistance in the main field rheostat of the generator which tends to take the wattless current, so as to improve its power factor. The generators tending to operate at the better power factor should have their rheostats set at the minimum-resistance position. In other words, the generator main field rheostats can be used to equalize the power factor of the generators.

An exciter having slow response makes the regulator response seem slow. Actually the response of the regulator depends upon how quickly the controlled exciter responds and to a large extent upon the amount of exciter-field rheostat in the circuit. Small exciters are usually faster to respond to a regulator than large ones because of the lower field-circuit inductance.

Care of Relay Contacts

The relay contacts operate directly across the exciter-field rheostat and from the maintenance viewpoint, deserve the most attention. These contacts should be inspected either once a week or once a month, depending upon the severity of service. The surfaces of the contacts can be kept in good condition by passing a magneto file between them with the regulator out of service. (A magneto file, which can be purchased in almost any hardware store, has a double cutting edge and measures approximately 1/32 in. thick.) After filing, the gap between the relay contacts should be adjusted so that it is 1/32 in. between open contacts. The life of the contacts is also increased by reversing the polarity by means of the reversing switches at the bottom of the regulator. The switches should be reversed at least once every 24 hours and reversing may be done without taking the regulator out of service.

If the duty on the relay contacts is not too heavy, the vibrating regulators can give satisfactory service and regulate the voltage very accurately. Where the contact burden is heavy, they may cause radio or telephone interference and are subject to considerable maintenance on the relay contacts, main contacts, pivots, bearings, springs, and dashpot.

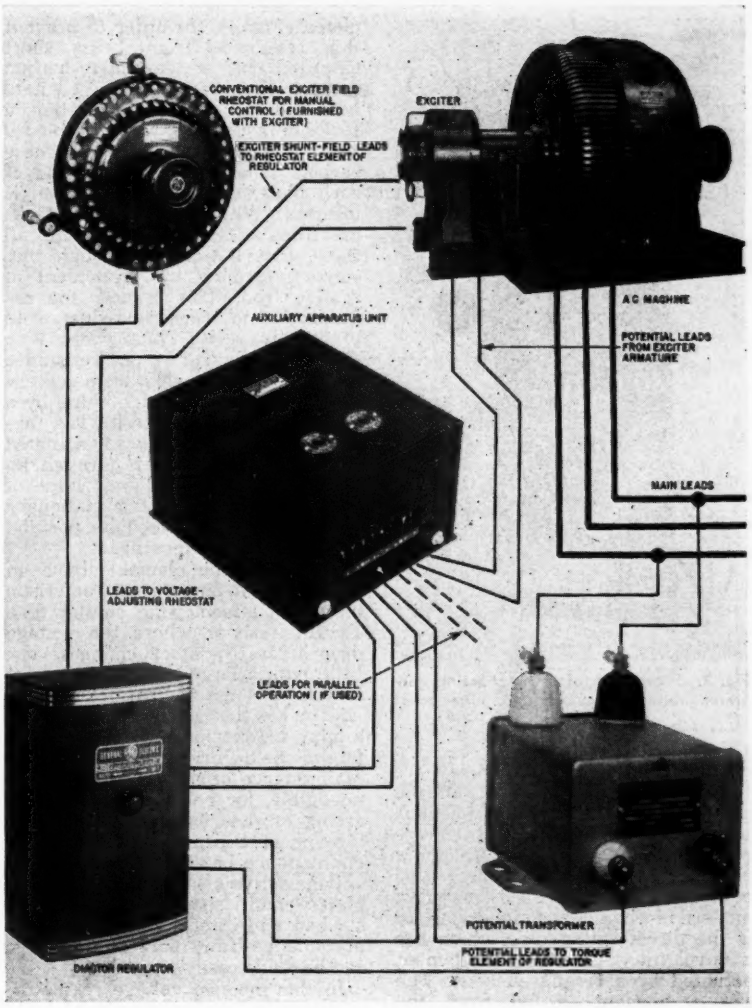

CONVENTIONAL EXCITER FIELD RHEOSTAT FOR MANUAL CONTROL (FURNISHED WITH EXCITER)
EXCITER SHUNT-FIELD LEADS TO RHEOSTAT ELEMENT OF REGULATOR
EXCITER
A-C MACHINE
AUXILIARY APPARATUS UNIT
POTENTIAL LEADS FROM EXCITER ARMATURE
MAIN LEADS
LEADS TO VOLTAGE-ADJUSTING RHEOSTAT
LEADS FOR PARALLEL OPERATION (IF USED)
POTENTIAL TRANSFORMER
POTENTIAL LEADS TO TORQUE ELEMENT OF REGULATOR
DASHPOT REGULATOR

Fig. 2. Pictorial diagram of the direct-acting generator-voltage regulator

Excitation Systems

It formerly was customary for stations of all sizes to have a common excitation bus with two or more exciters feeding the bus. This system was subject to many paralleling and load-division difficulties and required a voltage regulator large enough to control all exciters simultaneously. To obtain stable parallel operation the exciters had to be undercompounded and any slight failure of a voltage regulator could shut down the entire station.

For a number of years there has been a distinct tendency toward the unit system in which each a-c generator has a separate exciter (operating nonparallel) with individual regulator. This system is extremely flexible and has many advantages, such as simplicity, elimination of exciter paralleling troubles, elimination of generator-field rheostat operation and their losses, ease of control, and the automatic elimination of circulating, wattless current between regulated generators.

Progress and development mean

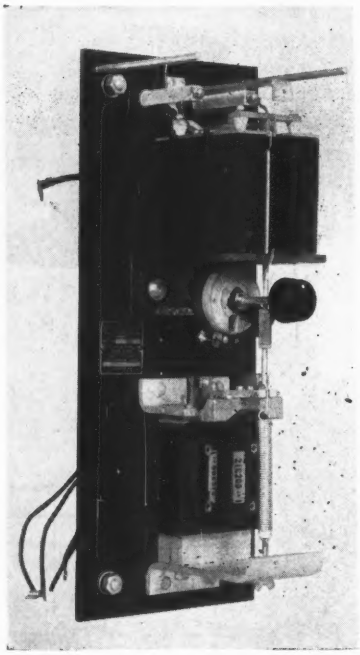


Fig. 3. Photograph of a direct-acting generator voltage regulator with the cover removed

change—the standards of today are the discards of tomorrow. In the past 12 years, much has been done to simplify the mechanical voltage regulators and to replace the more complicated vibrating contact-type equipments. The most popular, modern mechanical voltage regulator is the direct-acting type which has a novel integral rheostatic element actuated by a torque element. The torque element is fed from the generator a-c voltage through a potential transformer, manual voltage-adjusting rheostat, fixed resistor, stabilizer and full-wave, dry-type rectifier. The old style dashpot has been replaced by electrical damping.

The rheostatic element consists of a number of thin rectangular carbon or graphite plates stacked in a vertical position. The plates are separated and interlocked with one another at their mid-point by thin, rectangular nichrome spacers. The resistance of the rheostatic element is largely contact resistance between the nichrome spacers and the carbon

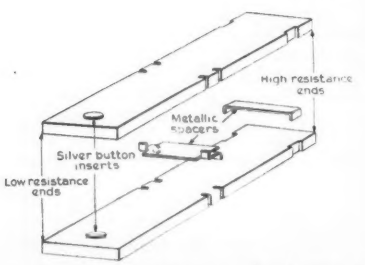


Fig. 4. Drawing of the resistance plates and metal spacers for the G-E generator-voltage regulator

plates (Fig. 4). In order to prevent this resistance from being short circuited by a carbon-to-carbon contact when the rheostatic element is in the high-resistance position, a series of insulated spacers are placed between the back ends of these carbon plates. In the front end of each plate, a solid silver button is inserted. When these carbon stacks are tilted in a forward position, all these silver buttons are brought into contact, forming the equivalent of a silver rod. This reduces the resistance of the rheostatic element to practically zero. Thus, there is a rheostatic element whose resistance may be easily varied from a very low value to a very high value by a slight tilting of the stack. The forward or backward tilting is actuated by the torque element through an insulated harness. At any value of steady load, the stack is stationary in the correct intermediate position and no parts are moving.

The rheostatic elements have an unusual volt-ampere characteristic in that it is somewhat similar to a Thyrite resistor where the voltage drop across the stack changes very little with a large change in current flowing through it. This characteristic makes the element applicable to a large number of exciters with different field-current requirements. Maintenance of the stacks is almost negligible, for normally there is no arcing or deterioration. Where the duty or watts per stack is heavy, the maintenance is still low because the voltage across each plate is low. The plates and spacers are simply stacked and interlocked so that replacement of any part of the stack can be made easily.

In this modern voltage regulator, the dashpot has been replaced by a stabilizer which produces electrical damping. The primary of the stabilizer is connected directly across the exciter armature voltage, while the secondary is connected in series with the voltage-sensitive coil of the regulator. There is no effect from the stabilizer on steady exciter voltage but only on exciter-voltage changes. In either direction of change of exciter voltage, it will damp the action of the voltage regulator.

Since the regulator rheostatic stacks are in series with an exciter-field rheostat, the duty or burden of the stacks can be substantially reduced by leaving some of the exciter-field rheostat in the circuit. On 125 v shunt exciters, which may have a ceiling armature voltage of 200 v or more, the ceiling voltage can be set by increasing the resistance with the exciter-field rheostat to limit the top voltage to approximately 150 v. Using the exciter-field rheostat as a limiting rheostat reduces any hunting tendency on the part of the equipment and reduces regulator maintenance.

A system which is hunting may be stabilized by the application of a relatively small force, if this force is applied in the proper phase relation with respect to the oscillation. It is desirable to have the stabilizing force proportional to the rate of change of the quantity, and, once the hunting has been stopped, it is desirable to reduce the stabilizing force to zero to prevent compounding effect.

With the direct-acting type of voltage regulator, hunting is more prevalent on shunt exciters than on compound-wound exciters. The worst offenders are shunt exciters with poor load regulation. On hand control, these exciters would droop badly in voltage when loaded. In cases of shunt exciters having extremely poor inherent load regulation, they can reverse polarity whenever resistance is inserted rapidly in the exciter-field circuit. On shunt exciters having interpoles, the load regulation can be improved by shifting the brushes of the exciter slightly against rotation, being careful not to shift so far that arcing occurs at the brushes. A slight backward shift of brushes is quite helpful in eliminating hunting. An effective method to prevent exciter reversal and eliminate hunting is obtained by adding a small bias feed across the field of the exciter. The bias feed can be supplied from a battery, if resistors are used to limit the current to approximately 1/10 amp. This low value of trickle feed can easily be obtained from an a-c supply using resistors and a dry-disc rectifier.

Operating the Regulator

It is generally most satisfactory to have the generator-voltage regulator left permanently in circuit when the exciter is direct-connected to the a-c generator even during the starting and stopping of the controlled unit. During such periods, the regulator has complete control and maintains practically normal a-c voltage, to the great relief of the operator.

If it is desired to take the regulator out of service, increase the resistance by turning the exciter-field rheostat slowly until the a-c voltage begins to drop slightly. At the same time keep compensating by turning the voltage -adjusting rheostat until it is in the extreme raise-position. This will close all the silver buttons so that the generator and exciter are subject to hand control. The regulator will be dormant at normal a-c voltage but will be able to act as an over-voltage protection equipment if the a-c voltage suddenly increases as it will if a large load is suddenly dropped. If it is desired to work on the regulator so that it can no longer operate as an over-voltage protection device, short circuit the two leads to the rheostatic stack. After completing work, remove the shorting connector.

To replace the regulator in serv-

ice, turn the voltage-adjusting rheostat slowly back to its original position, and at the same time, turn the exciter-field rheostat slowly to the predetermined point.

Parallel Operation

Many voltage regulators are required to operate in parallel, and with an individual voltage regulator on each unit, automatic elimination of wattless current swings between each generator is easily accomplished. This is done with a current transformer for each generator and a potentiometer-type compensating rheostat in each regulator auxiliary box. The action of the compensating rheostat is to reduce the reactive kva of its generator, always tending to signal the control element of its regulator to go toward unity power factor. This effect is especially valuable during system disturbances, since the compensating action makes each regulator raise or lower its regulated voltage to reduce circulating current and thus tends to keep the generators in step. If the regulated generators are over-excited, operating at lagging power factor, the effect will be to reduce excitation. If one generator happens to be under-excited, operating at a leading power factor, the effect will be to immediately raise the excitation, reducing the circulating current, and preventing the generator from falling out of step.

Indirect-Acting Voltage Regulators

Simplicity, sturdiness, fast action when necessary, and extremely low maintenance characterize the rheostatic generator-voltage regulator. This type of regulator is particularly adapted to generators with exciters whose fields are separately excited from constant-voltage pilot exciters (Fig. 5).

As long as the a-c voltage is within 0.5 per cent of normal, the regulator equipment remains inoperative except that a tiny synchronous motor rotates the notching cam contact and the center-disk contact. Upon *slight* voltage changes, the regulator simply operates the motorized exciter-field rheostat; upon voltage changes of two per cent or more, a large change in exciter voltage is obtained by the action of high-speed relays commanded by the regulator. The raising relay can impose full field upon the main exciter; the lowering relay inserts a large block or resistance in the main exciter field. Simultaneously with the action of either high-speed relay, the exciter-field rheostate operates to assume the new position for the changed load condition. The bridge type rheostat makes it possible to obtain a zero or slightly negative voltage across the collector rings. This is desirable in case of a loss-of-load condition on water-driven generators; it allows the maximum amount of lagging kva to be supplied by a sychronous condenser.

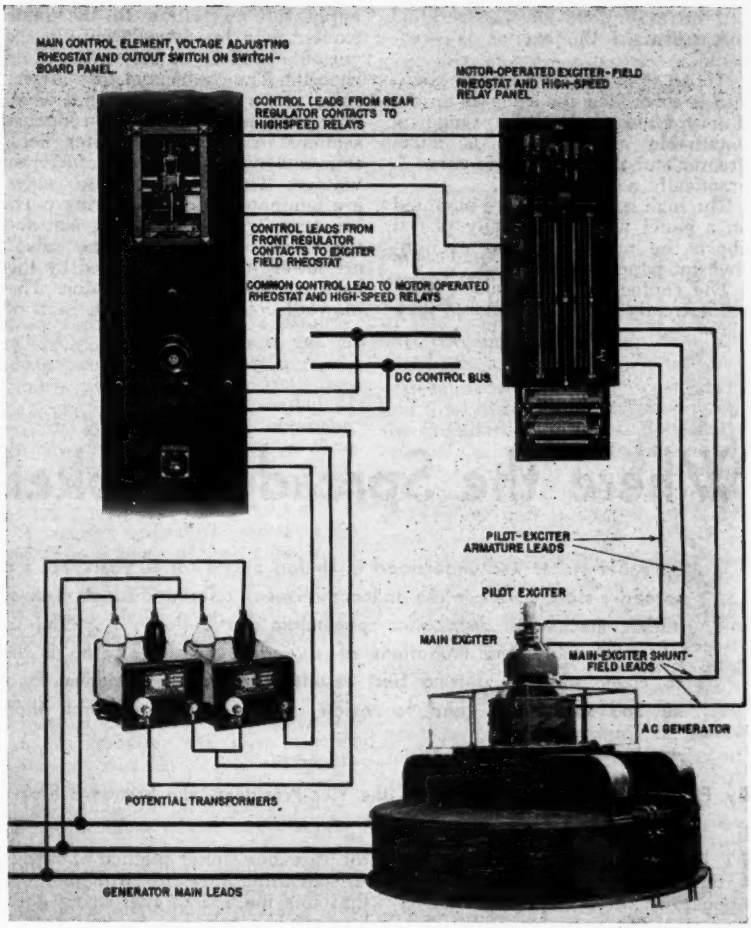

MAIN CONTROL ELEMENT, VOLTAGE ADJUSTING RHEOSTAT AND CUTOUT SWITCH ON SWITCHBOARD PANEL
MOTOR-OPERATED EXCITER-FIELD RHEOSTAT AND HIGH-SPEED RELAY PANEL
CONTROL LEADS FROM REAR REGULATOR CONTACTS TO HIGHSPEED RELAYS
CONTROL LEADS FROM FRONT REGULATOR CONTACTS TO EXCITER FIELD RHEOSTAT
COMMON CONTROL LEAD TO MOTOR OPERATED RHEOSTAT AND HIGH-SPEED RELAYS
DC CONTROL BUS
PILOT-EXCITER ARMATURE LEADS
PILOT EXCITER
MAIN EXCITER
MAIN-EXCITER SHUNT-FIELD LEADS
AC GENERATOR
POTENTIAL TRANSFORMERS
GENERATOR MAIN LEADS

Fig. 5. Pictorial Diagram of indirect-acting generator-voltage regulator

The regulator equipment consists of three parts: the motor-operated exciter-field rheostat; the control head; and the high-speed relays.

The control head, which may be mounted as a unit upon the switchboard panel, consists mainly of a three-phase element called a torque motor, the rotor of which is stalled and whose torque is opposed by a helical spring. The three-phase stator with external resistors and a three-phase adjusting rheostat is connected to the secondaries of two open-delta potential transformers so that an average of the three-phase voltages is regulated. The rotor consists of a hollow cast-iron cylinder mounted on a ball-bearing supported steel shaft which carries an insulated lever arm with two pairs of springs contacts (front and back) and a damping device. A tiny synchronous motor continuously drives the center-cam contact and disk contact at four rpm. This prevents contact sticking and keeps the contact surface clean. The shape of the cam contact, together with the permanent magnet damping device, prevents over-shooting of the rheostat and regulator hunting. The control head commands all action, varying from no action when the a-c voltage is normal to full action of the high-speed relay and motor-operated rheostat during disturbances.

The motor-operated exciter field rheostats haxe 200 steps so proportioned that the main exciter voltage does not change more than 0.75 per cent per step over the entire operating range.

Bridge-type connections are used whenever the exciter field is separately excited. This type is capable of changing the main exciter voltage over an extremely wide range without using high-resistance wires as in the series type. The sections of resistance are selected to keep the losses low and to obtain equal volts per step throughout the entire operating exciter-voltage range. The bridge is made by two permanent sections of resistance and two variable sections, beside the two field reducing sections which are only inserted during over-voltage conditions. The arms of the variable sections are mechanically connected but electrically separate and considered as one arm. When the arm is at the extreme "down" position, a slight reverse current is imposed

on the main field so that residual magnetism of the exciter is overcome.

To an operator, the bridge rheostat is controlled the same as an ordinary rheostat but the range in obtainable exciter volts is much greater and the volt-button curve is practically a straight line.

The high speed relays are mounted on a panel which is usually placed above the motor-operated exciter-rheostat panel.

The contacts of the "raise" relay are normally open; when closed they apply full excitation to the main exciter field by short circuiting the variable sections of the exciter-field rheostat. The contacts of the "lower" relay are normally closed, but when energized insert the field-reducing sections in the main exciter field, thus causing a rapid decay of exciter voltage. The cores of these relays are laminated and the moving parts are very light. As a result, fast action is obtained whenever the "raise" or "lower" relay is energized by the back contacts of the regulator. The blowout coil, in series with each of the relay contacts, make it possible to control heavy field currents successfully. Since these relays operate only upon sudden changes in a-c voltage, maintenance is reduced to a minimum.

The regulator is easily placed in service or taken out of service by a turn-button type of transfer switch, which may be operated when both sets of contacts are open. If desired, pilot lamps can be added to indicate this condition. They are particularly useful when the regulator is located remote from the operator.

Where the Spreader Stoker Stands Today

Spreader stoker well understood in United States for 40 years; not a new idea . . . By 1930 over 10,000 spreader stokers were in use on locomotives . . . Three distinct classes of spreaders; steam jet distribution, mechanical distribution, pneumatic distribution . . . Why spreader stoker use is increasing . . . Flexibility and limitations of spreader stoker . . . This is first of three articles, the second to cover ways of getting best results with stokers, handling fly ash, cinder reburning, over-fire air and so on, the third to review latest test and research that will help the stoker operator

By **FRED D. MOSHER** Assistant to the Vice-President, The Standard Stoker Co., Inc.

IT HAS BEEN erroneously stated that the spreader stoker reached a generally "accepted" stage during the late 1920's or early 1930's. This, as in so many other instances, has frequently led to the conclusion that the spreader stoker method of firing is something new in principle, or that this method of fuel firing and burning has only been recently understood. But spreader stoker firing has been quite well understood for about 40 years in the United States; by 1930 more than 10,000 spreaders were in successful operation on locomotives, having superseded underfeeds in this service prior to World War I. The spreader stoker principle of firing was actually developed into an accepted, practical means of burning coal on locomotives; even the most recent applications in stationary power plant practice do not approach the capacities or flexibility of locomotive spreaders.

There are three distinct classes of spreader stokers with respect to the means of distributing coal to either stationary or traveling grates. These three types are: steam jet distribution, pneumatic distribution, and mechanical distribution. While some of the earlier and most successful spreader stokers used oscillating paddles moving in a horizontal plane, Fig. 1, modern spreaders using mechanical methods of distribution adhere almost entirely to rotors of one form or another.

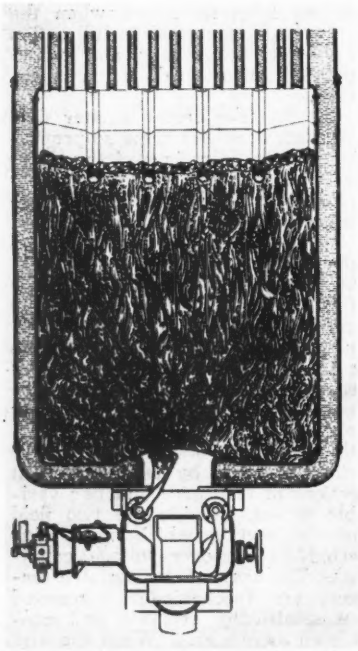


Fig. 1. Early form of the spreader stoker, with mechanical "shovel" distribution

Types of Spreader Stokers

A spreader stoker using steam jets for distributing the coal is shown in Fig. 2. This type of stoker is used extensively in locomotive service and more recently in "package" mobile power plants. While there probably have been more steam spread-

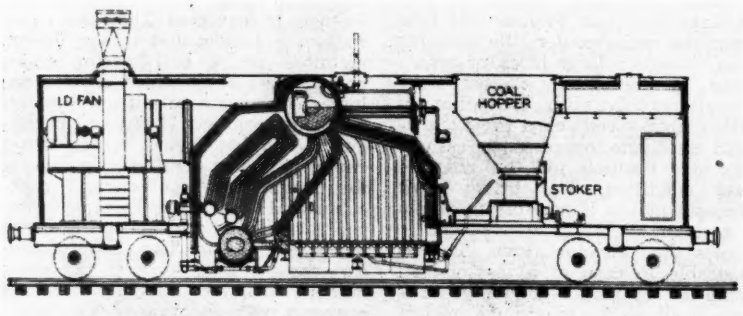


Fig. 2. Spreader stoker using screw feed and steam jet distribution, firing "package" boiler for mobile power plant

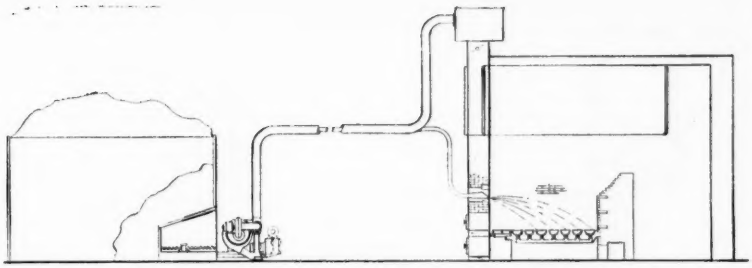


Fig. 3. Pneumatic spreader stoker of recent design

ers put in service than any other type, their use is confined for the most part to mobile power plants, such as the one shown in Fig. 2, and to locomotives and steamboats.

One of the outstanding features of the steam-type spreader is its ability to handle a wide range of coals from run-of-mine to all slack. Coupled with its ability to respond to rapid load changes and its fuel flexibility, it has pre-empted the mobile power field. Its status is not likely to change greatly.

Pneumatic spreader stokers have for some time been accepted as a satisfactory means of firing boilers in institutions and the smaller industrial power plants. A pneumatic type stoker of recent design and application is shown in Fig. 3. In this type of pneumatic spreader stoker the coal is fed from the bin by a conveyor screw and picked up by the air stream to be carried to the nozzle distributors set in the boiler front. The coal is fed to the furnace through a pipe, which is jacketed by a larger pipe. Hot gases from the boiler are drawn through the outer pipe drying the coal in the inner pipe. All the circulating gas is taken into the blower and returned to the furnace in the coal stream.

The more popular type of spreader stoker is the mechanical distributor type with either the "overthrow" or "underthrow" rotor. Fig. 4 shows a typical spreader stoker using an underthrow rotor. The coal is fed from the hopper by a rotating agitator to a pusher, which regulates the amount of coal picked up by the distributing rotor or reel. Fig. 5 shows a spreader stoker with a mechanical distributor firing on a traveling grate. Such a combination of stoker and traveling grate is commonly termed a continuous-ash-disposal spreader stoker.

The Trend to Spreader Stokers

As fuel burning went from hand-firing to mechanical firing and as the electric power industry developed, the various types of underfeed stokers became quite popular. Underfeed stokers gave way, first, to pulverized coal burning for the larger installations and recently to spreader stokers in the whole field previously handled by the underfeeds.

Spreader stokers are becoming increasingly popular for a number of reasons. In the earlier days, "standby" boilers were in common use in power plants and flexibility and reliability were often obtained in this manner. Outages were accepted as part of the business and extended periods of idleness for repairs were quite common. During this period, the underfeed stoker was the preferred mechanical firing device.

Spreaders appeal to power plant operators because of their high availability and low maintenance. The trend away from "standby" boilers or a reduction in such units makes the spreader much more attractive than the underfeed, which may have high operating and maintenance costs. Coals must be reasonably well selected for the underfeed while the modern spreader will burn a wide range of coals. First costs and installation costs are lower for spreader stokers than for underfeeds, particularly for those of the larger capacities.

In modern boiler practice, steam generators with high efficiency along with high availability make it desirable to install fuel burning equipment with similar characteristics. Either the stationary grate or traveling grate stoker have high availability with a minimum of maintenance. The proper selection of a steam generator and spreader stoker gives the operator a combination that will "stay on the line" and consequently his operating difficulties are minimized.

An important feature of the spreader stoker is its applicability to existing boiler installations. Usually a spreader stoker can be successfully applied to boilers above 100 hp. In periods such as we have been witnessing, when labor costs are high, the low-cost spreader is an attractive replacement for hand-firing.

In the larger-capacity boilers the spreader stoker with continuous ash disposal, or traveling grates, is presently competing actively with pulverized coal. However, even though there is a trend to larger capacities in this respect, the spreader stoker with traveling grates is not likely to invade the utility field.

Because of lower first cost, load and fuel flexibility and simplicity, the spreader stoker will undoubtedly cut deeply into the larger industrial power plant field where at present pulverized coal and multiple retort stokers are now in use.

Flexibilities and Limitations of Spreader Stokers

Recently an author stated that (paraphrased) "the spreader stoker doesn't care what you feed it as long as it can be burned." It is difficult to endorse this statement. The spreader stoker has amazing flexibility, inasmuch as it will burn an amazingly wide range of coals, but a stoker must burn its fuel successfully to be justified and it must also contribute its share to good overall plant performance.

To understand just how flexible a spreader stoker is regarding fuel selection, one must understand the basic principle of the spreader which accounts, in part, for its popularity. All are agreed that the thin, uniform fuel bed of the spreader is its stock in trade. Reasoning further, it is logical to conclude that any fuel that permits uniform distribution over the grates and is conducive to a uniform, thin fuel bed on the grate

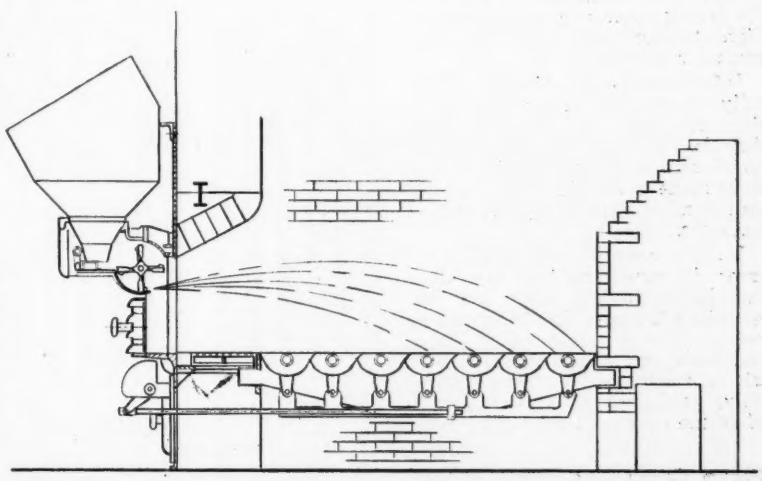


Fig. 4. Typical modern spreader stoker with underthrow rotor and stationary dumping grate

is a satisfactory spreader stoker coal.

This fundamental of the spreader stoker — the even distribution and uniformly thin fuel bed — actually excludes certain classes of coal and coals of indiscriminate size consist, where the top sizes exceed, say, 1 in. to 1¼ in. To get top performance from a spreader stoker, a nut and slack size consist is the best fuel; in this consist the various sizes should be fairly well proportioned. These proportions of sizes are necessary to give the right amount of suspension burning and to enable proper distribution of particles on the grate. There is a right fuel for the spreader stoker and it does not include all wet slack, oversize lumps or disproportionate amounts of slack in nut and slack consists.

Spreader stokers have their limitations with respect to heat release per square foot of grate or practically any other yardstick one may choose to select. This is not a defect of the stoker but a limitation imposed by the necessity for providing all-around reliability and maximum performance in the whole steam generation system, including boiler and appurtenances. The high firing rates (in many instances over 200 lb per sq ft of grate per hour) reached in locomotive spreader stoker practice are in great part due to the type of boiler and disposition of heat absorbing surfaces.

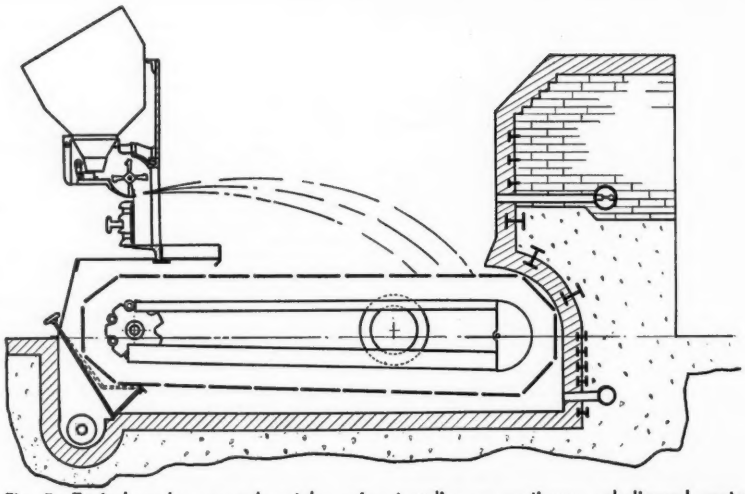


Fig. 5. Typical modern spreader stoker using traveling or continuous ash-disposal grate

Spreader stokers, of course, have definite limitations with respect to cinder and flyash loss; today, in view of stringent smoke ordinances, flyash emission must be considered seriously.

Steps now being taken in cooperation with the coal industry and stoker manufacturers will undoubtedly determine more definitely the place of the spreader stoker in the power plant field and define more clearly its advantage and limitations.

DON'T WORRY ABOUT NEW THREAD STANDARDS

WIDESPREAD publicity following adoption of unified screw thread standards by the United States, Canada and Britain, has aroused questions among plant engineers who use quantities of bolts, nuts, and other threaded fasteners in maintenance and repair work.

What is different? Fortunately for American engineers, the new unified standards conform to the American 60-deg thread angle rather than the British 55-deg angle. From the American standpoint, the principal change is increased tolerance in clearance between male and female threads, eliminating excessively tight fits during wrenching and seizure at high temperatures, and allowing room for plating.

Is fastener strength affected? Naturally the question arises as to relative strengths of old and new threads. The answer is that there is no change one way or the other. Bolts made to the old or new American standards are all equally strong fasteners.

Is fastener assembly affected? In all cases the new American standards can be assembled with the old American threads. This is fortunate, because the procurement of gages and tools and using up stock will take a relatively long time. Naturally, producers of fasteners will adopt the new tools needed for pro-

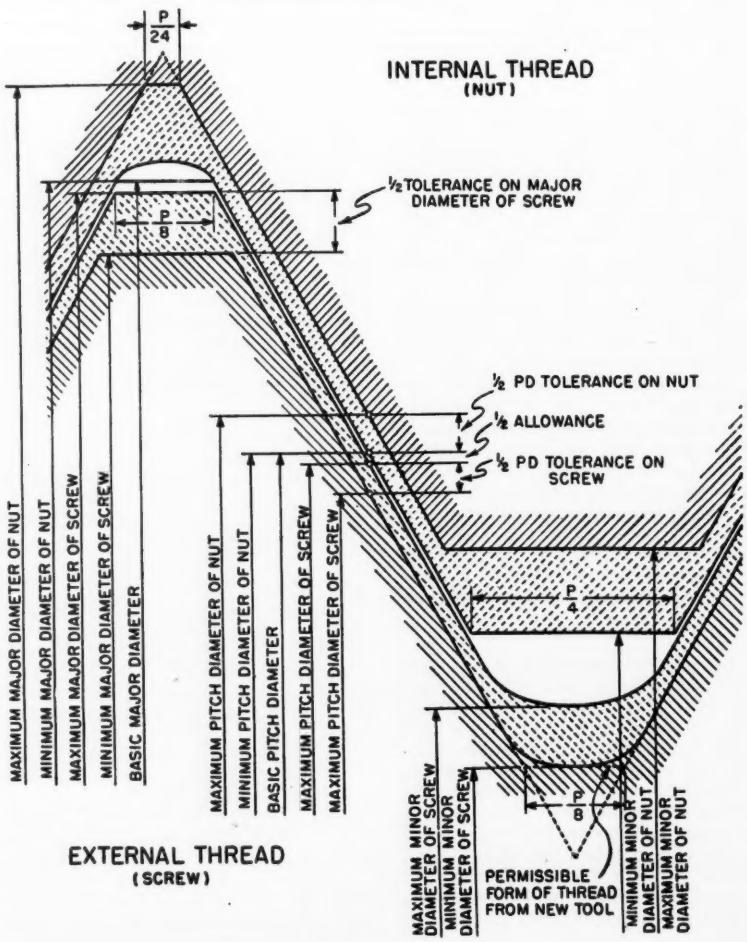


Diagram showing Class 2A and 2B tolerances allowance and crest clearances

ducing the new threads, as fast as the old tools wear out, but production of both types will go on for some time before conversion is complete. It should be remembered that the differences in dimensions are in most cases so minute that only with close gages in the hands of experienced men can the differences be shown.

Should the new standard be specified? Specify the new standard now with these reservations: Where the screw is to be assembled into a precision tapped hole and a wrench-tight stud fit is desired, the purchaser should state the fact definitely. If the assembly is with a nut or in a tapped hole where a free fit is desired, there are few, if any, cases where either the new or the old standard thread would not be fully satisfactory.

Are present fastener stocks obsolete? The answer is "No." It would be extremely wasteful and unnecessary to scrap present stocks. *From Fasteners, a publication of American Institute of Bolt, Nut and Rivet Manufacturers, Cleveland, Ohio.*

Cleaning Large Hydraulic Turbine Runners

By H. B. McDERMID

CLEANING the complicated shape of a modern, large hydraulic turbine runner by hand is a big job as the casting comes from the foundry. It takes a lot of man-hours and many days of elapsed time, and often results in the marring of the edges of the vanes. This irritates the designing engineer, who has spent plenty of effort to get all those curves and surfaces just right, so that the water may flow through its passages smoothly and so create no disturbances in the water currents that could cut down the wheel's efficiency. A smooth unmarred job is also to be desired by all concerned in the matter of looks, but is very hard to secure when removing stubborn reinforcing rods and hard baked core sand by hand. So the engineer was alert to find an improved method of doing this hard and delicate job.

When walking through the immense works one day, he saw a worn-out boring mill being dismantled, for its life as a machine tool was ended, and the thought came to him to use parts of it in the foundry.

First, in a part of the foundry yard, a concrete lined pit was made, that could be properly served by existing cranes; one side of the pit had an adequate sump to hold water, which, when it was used, could be collected and re-used again, as often as might be desirable. A 6-in. high-pressure centrifugal pump was mounted on the pit rim, with its suction piped to the sump and its 300-psig nozzle discharging through a solidly-anchored swivel in a steel plate screen, slitted so the operator could see where he was playing the powerful stream without being unduly exposed to the splashing water flying back from the work.

The boring mill, stripped of all its upper works but with its frame and platen intact, was installed on the opposite side of the pit, with its motor properly protected from flying water, as was the one on the pump. Then the shapeless lump of sand and iron that was the uncleaned casting, just as it came from the mold, was placed on the platen, and started revolving slowly. The pump then started a heavy stream of water playing on the runner casting revolving on the old boring mill platen. The sand and water ran to the sump, the sand to be salvaged by a clamshell bucket for further use in the foundry, the water to begin at once another trip through the hydraulic system.

In a very few minutes, the runner casting was perfectly cleaned without any damage at all, needing only sprue removal and like minor details to be ready for the machine shop in the elapsed time of a very few hours, where the same result, with some damage, had previously taken weeks.

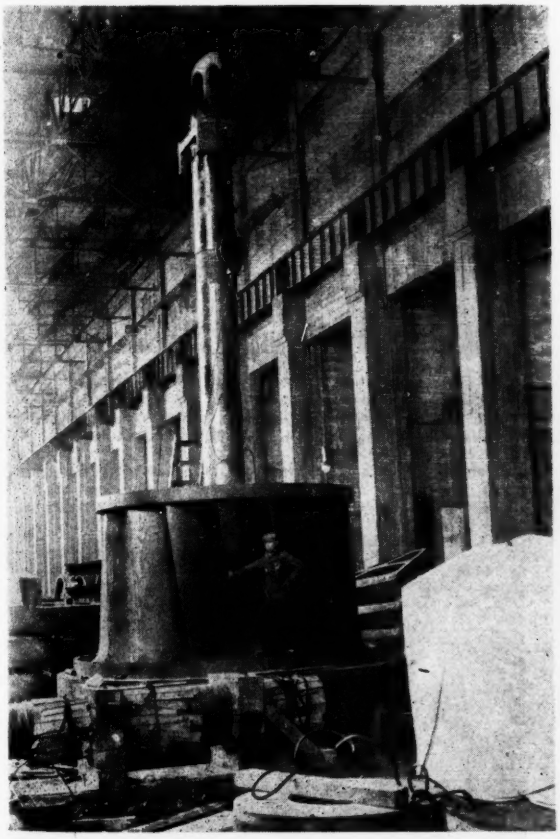


Fig. 1. View of Francis-Type runner in manufacturer's shop, after casting has been cleaned up

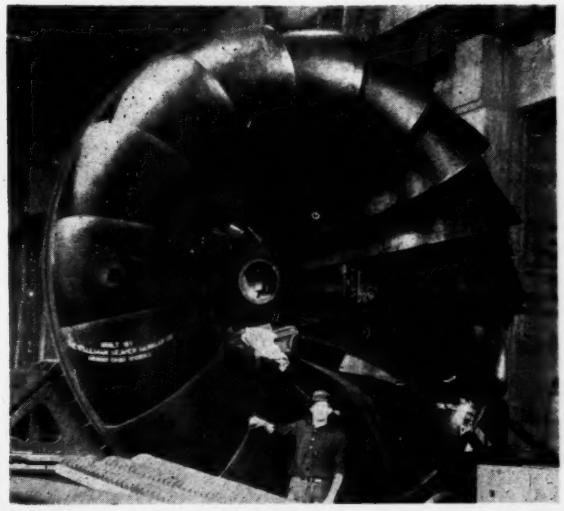
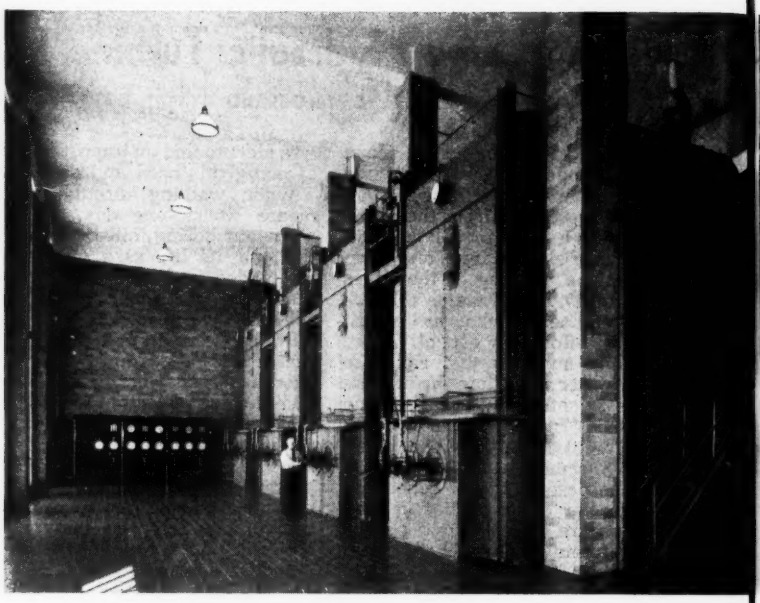


Fig. 2. Another hydraulic turbine runner, in shop, showing why care in cleaning castings is desirable

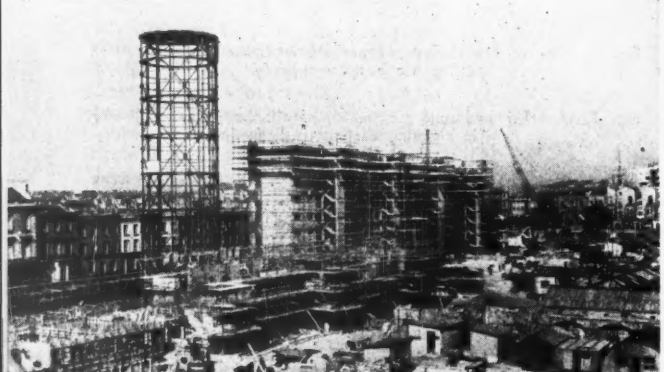
Power Generation

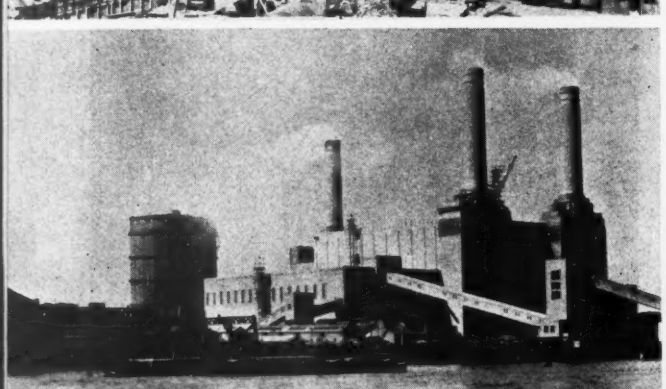
Except for the hard hats and jackhammers, which identify construction workers the world over, these men working high on the sheer rock face of the canyon wall that will form the right abutment for the Bureau of Reclamation's Hungry Horse Dam might be mistaken for mountain climbers scaling an Alpine peak

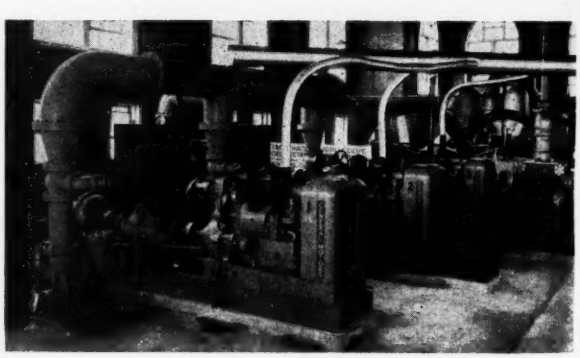


Father Flanagan's Boys Town in Nebraska, near Omaha, will be properly supplied with heating, laundry and cooking steam by these four new B & W boilers, with Plibrico settings, fired by Zinc oil burners and all under Republic automatic combustion control

Here, at top, is the new Pimlico Housting Project under construction in the Westminster Precinct of London, England, for which hot tap water and space heating will be provided by heat generated at Battersea Power Plant below. Heat transmitted across the river from the power plant will be stored in the accumulator at left of apartment building. Economical, eh, what! old chap?

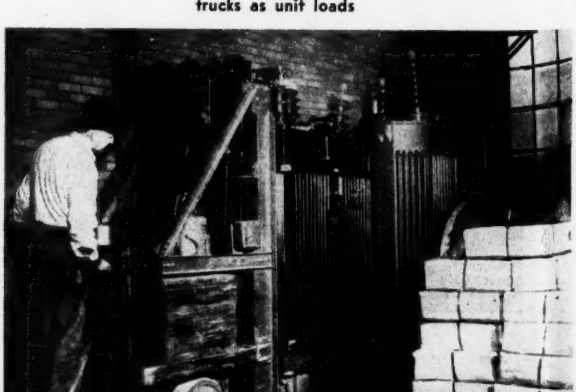




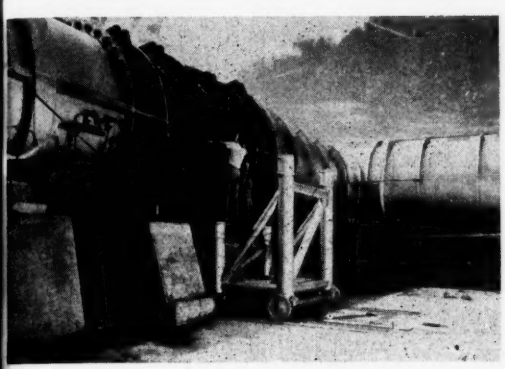


Three new combination Diesel-electric pumps with total capacity of 9,720,000 gpd have been added to the water supply system of Pontiac, Mich. G-M Diesel, Peerless pump, Westinghouse motor, mounted in line on one base form each unit

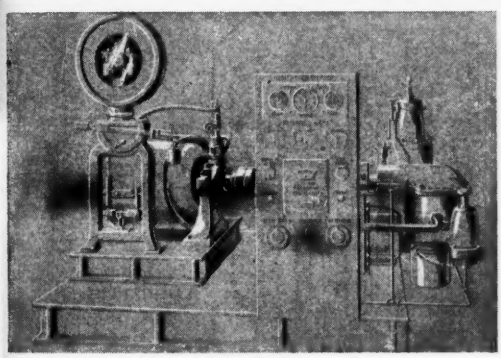
One of West Penn Power Company's large fleet of battery-powered trucks positions a 6,000 lb transformer in the company's warehouse. All stored equipment is palletized and handled by fork trucks as unit loads



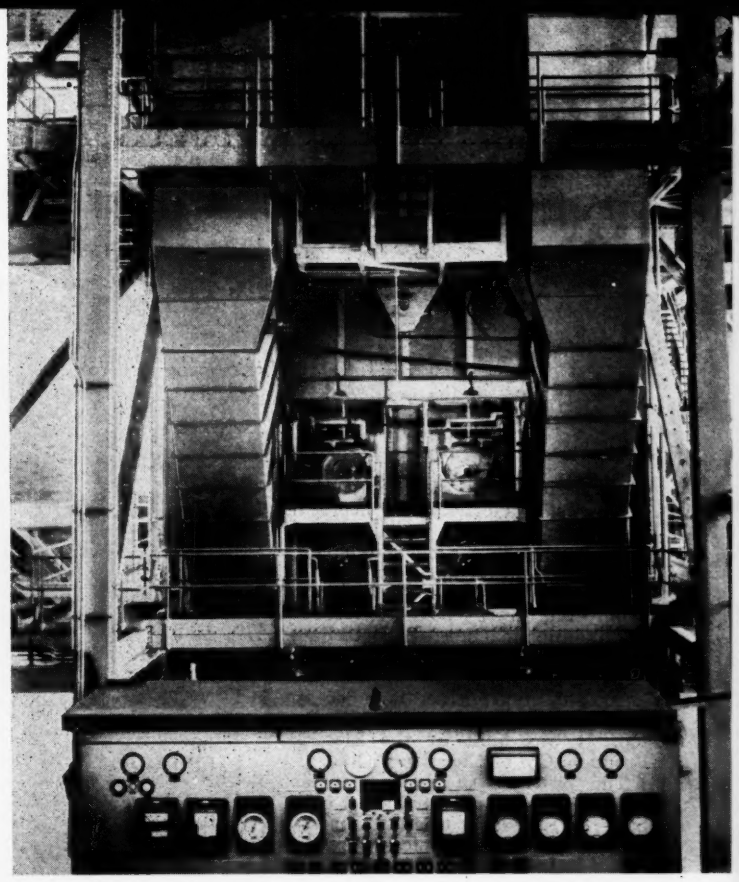
NEWS REEL



In new 4 by 4 ft supersonic pressure tunnel at Langley Aeronautical Laboratory, a key element is the 870,000 cfm Allis-Chalmers axial-flow compressor



Complete turbine-dynamometer set like this is now being furnished by General Electric for educational laboratories. Turbine type DP-25, 100 hp, 4600 rpm. Indicator dynamometer type TH-4G, 150 hp, 3000-6000 rpm



View of the dual circulation steam generating unit, one of two installed at the Whiting Refinery of the Standard Oil Co. (Indiana). This shows part of burner and duct arrangement. Lower burners behind instrument panel. The dual circulation unit was developed by Foster-Wheeler Corp. to minimize silica concentration and blowdown losses. This Whiting installation was described in detail in *Power Generation*, April, May, August, 1949 issues

Right: W. A. Yost, manager of Allis-Chalmers steam turbine department, and C. F. John, vice-president, Wisconsin Electric Power Co., watch while Harry Shaver, engineer-in-charge of the utility's Port Washington (Wis.) power plant opens the throttle valve on new No. 4 unit.

In this station, all are Allis-Chalmers 80,000-kw reheat machines. The new turbine-generator has throttle steam conditions of 1,380 psig and 900 F, with reheat to 900 F and exhaust at 29½ Hg. A fifth 80,000-kw unit is being built by Allis-Chalmers for installation in 1950. Unit No. 3, is described in *Power Generation*, March 1949 issue

Oscillograph equipment used to record lightning impulses on antenna atop Empire State Building in New York City. Lightning has struck it 24 times this summer, say General Electric engineers in charge of research

Homopolar Generator To Excite Synchro-cyclotron at Carnegie Tech

Improved design of homopolar generator to supply 21,000 amp at 18.7 v to the exciting magnets of the new synchro-cyclotron at the Carnegie Institute of Technology

A FEATURE OF considerable interest to electrical engineers in connection with the installation of the new Synchro-cyclotron at the Carnegie Institute of Technology is the use of a homopolar generator to supply the direct current for exciting the huge magnets. This machine is a 400 kw, 21,000 amp unit operating at 18.7 v. It is a vertical machine of the axial type, driven by a 600-hy synchronous motor mounted at the top. It was built by the Electric Products Co. of Cleveland, Ohio.

The principle of the homopolar generator is not new, indeed it goes back to Faraday's original experiments in electrodynamics. Faraday showed that when a metal strip is moved between the poles of a magnet as shown in Fig. 1 so as to cut the lines of force, an emf is established between the brushes a and b, and if the brushes are connected by an external conductor a continuous current will flow. Faraday's original generator worked on this principle. His arrangement was a copper disc which rotated between the poles of a horseshoe magnet.

Little practical use was ever made of this principle in the actual construction of generators, however. For commercial power service the voltage that can be obtained from this type of machine is too low and while they have been constructed for use in applications where very low emfs are required they have been heavy and expensive and troublesome to operate because of the large number of brushes required. In 1934 a 1125-kw, 7½-v, 150,000 amp, 514 rpm homopolar generator was built and installed in

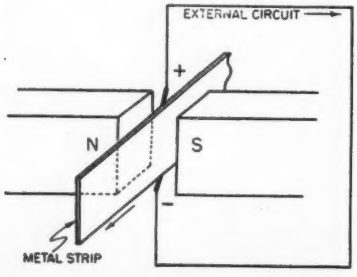


Fig. 1. Diagram illustrating Faraday's principle

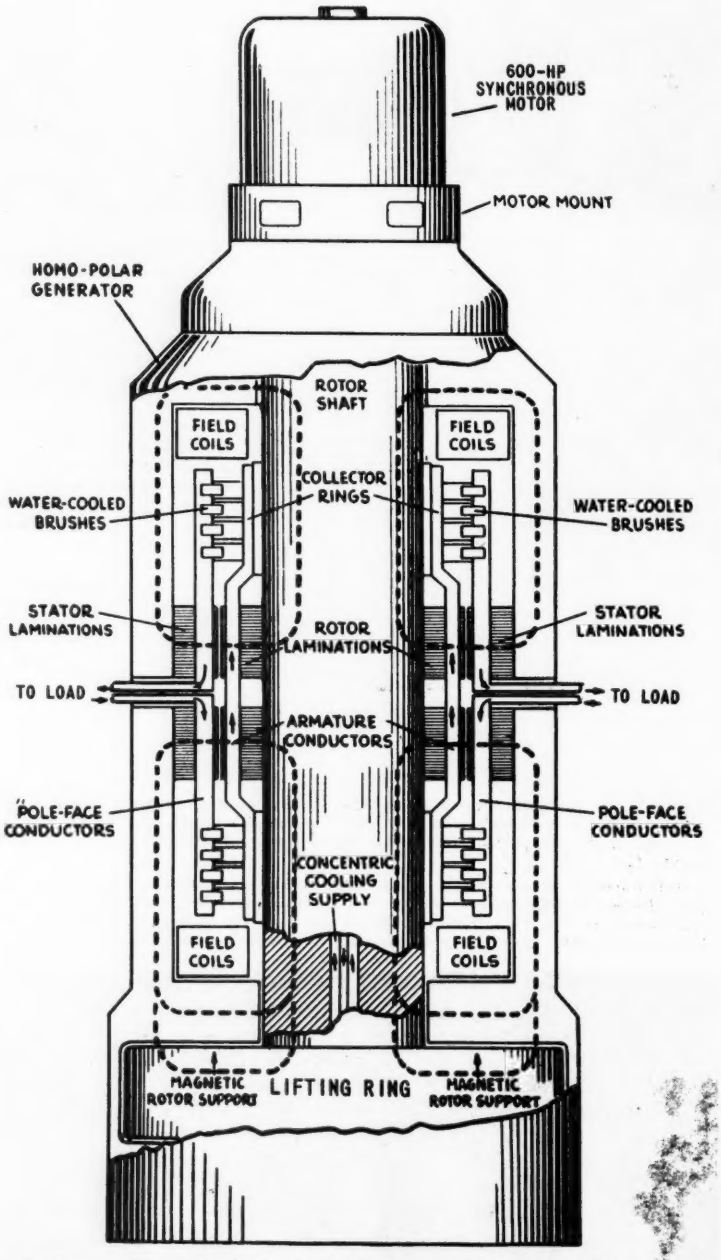


Fig. 2. Cross section of the 400-kw, homopolar generator built by The Electric Products Company

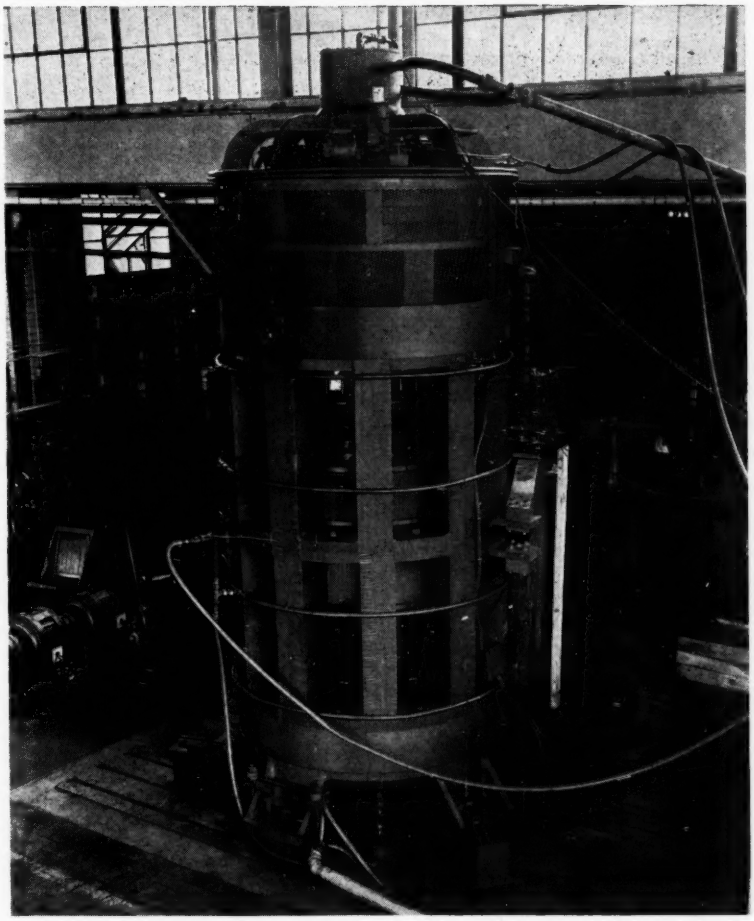


Fig. 3. The homopolar generator in final stages of mechanical tests prior to testing it electrically. The brushes with accompanying water-cooling system are not yet installed

a steel mill in this country for use in pipe welding. This was the largest machine of this kind ever built.

For certain purposes, however, the homopolar generator has advantages. It is the only type of generator that produces a pure continuous direct current. Since an absolutely steady direct current is needed in the excitation of the synchro-cyclotron magnets, this type of generator was selected.

In deciding upon the homopolar generator for the Carnegie installation consideration was given to a number of recent improvements that had been made in the design of these machines. One serious fault of earlier homopolar generators was poor voltage regulation. This has been corrected in the new machine built by The Electric Products and which was designed by J. V. Caputo who became interested in the homopolar design in 1907 and has over the years investigated means of perfecting this type of generator. The problem of poor voltage regulation has been solved by his method of compensation and has opened the door for further homopolar generator development. Mr. Caputo's first commercial design was made several years ago for a rather special application —resistance welding. The Electric Products Co. co-operated in the construction and test of this first unit. That unit has now been in operation for over a year with extremely satisfactory results. Based on its experience with this first perfected homopolar generator, The Electric Products Co. accepted the assignment of building the 21,000 amp. 18.7 v. machine for Carnegie Institute of Technology.

Basically the homopolar design, improved and patented by J. V. Caputo and manufactured by The Electric Products Co., incorporates four features that make this design commercially practical. They are: (1) Caputo compensation, (2) vertical design, (3) magnetic lift, (4) water-cooling.

Caputo Compensation

The induced armature voltage is dependent upon the amount of flux and the speed of the armature. This is because the homopolar generator has, in effect, only one armature conductor and the voltage is dependent upon the lines of flux cut by this conductor. All flux passes axially along the rotor core and through the collector rings. The homopolar generator is actually two generators back to back. The armature conductors are joined directly in series so that their induced voltages are additive. Each unit develops only half of the required voltage. This type of construction holds the diameter of the collector rings within reasonable ring velocities.

Referring to the attached diagram, the dotted lines show the magnetic flux paths. The direction of the flux is opposite in the two ends of the rotor. There is no tendency for interaction between the two magnetic circuits and the polarities of the induced voltages are additive.

Compensation by the Caputo method maintains constant reluctance in the total magnetic circuit. It is effected by bringing the brush leads out to pole-face conductors which pass through the stator laminations to the terminals. The load current in these conductors is opposite in direction to the current in the armature conductors. The armature conductors are located close to the air gap and directly opposite the pole-face conductors. Caputo's method eliminates: (1) magnetic coupling to the main air gap, (2) voltage unbalance, and (3) internal circulating current. The net result is minimum armature reaction and good voltage regulation.

A further compounding effect is obtained by skewing the rotor bars. By doing this, the load current flows partially around the rotor and these ampere-turns aid the field excitation coil. With this added compounding effect, it is entirely feasible to produce a voltage rise rather than a voltage drop, if desired.

Vertical Design

This design permits easy accessibility for routine preventive maintenance and considerable amount of floor space is saved. The water-cooling system of the generator performs more satisfactorily with a vertically designed machine than with one of horizontal design.

Magnetic Lift

The thrust load on the bottom bearing is minimized by this new concept of engineering. Part of the field flux of the bottom generator unit is allowed to leak into the lifting ring mounted on the rotor, and thence to the rotor. This flux produces a lifting force to counterbalance thrust due to the weight of the rotor.

Water-Cooling

The brushes and collector rings are water-cooled because of the heavy currents carried. Made of copper graphite powder, the brushes are molded with integral water-cooling tubes. The collector rings are cooled by water introduced by a dip tube in the hollow shaft. Incoming water flows up around the dip tube until it encounters radial holes that lead to the lower portion

(Continued on page 102)

Boiler Feed Pump Operation in 2-Unit Power Plants

In multiple-unit installations, where feedwater cycles of separate turbine generator units are integrated following boiler feed pump discharge, operating problems arise, especially when turbines operate at different loads . . . Pumps take suction at different pressures, temperatures and quantities, but must operate in parallel at discharge . . . Standby pump operation . . . Specific case analyzed . . . Satisfactory methods of operation are proposed to solve these problems

By **I. J. KARASSIK** Assistant to Manager, Centrifugal Pump Division Worthington Pump & Machinery Corp.

STEAM POWER PLANTS embodying a single turbine-generator unit are rapidly assuming the characteristics of prehistoric rarities in these days of expanding electric power generation. The multiplication of turbine-generator units obviously carries with it many new problems, one of which has proved to be particularly vexing. This problem has to do with the operation of boiler feed pumps in multple-unit installations where the feedwater cycle is entirely separate for each unit from the turbine-generator exhaust on through the condenser, condensate pump and deaerating heater to the boiler feed pump suction, but becomes integrated from the boiler feed pump discharge on. At that point, the individual boiler feed pumps discharge into a common header which serves all the installed boilers.

Typical 2-Unit Plant

Such a cycle is illustrated schematically in Fig. 1. For simplification, all the valves but two have been omitted. These two valves are indicated in the two suction lines leading to the turbine-driven standby pump from the two deaerators and are used to isolate this pump from one or the other of the deaerators, depending upon which of the units is temporarily being served by the standby pumps. It should be noted that the two turbine-generators may operate at different loads, hence the extraction bleed pressures to the two deaerating heaters may vary considerably. Thus it is impossible to interconnect the pump suction headers. For the same reason of simplification, alternate feedwater routing lines, closed stage heaters and surge tanks have been omitted.

In such an installation, it is generally the practice to start the turbine-driven standby boiler feed pump automatically if either of the motor-driven pumps fail to develop sufficient pressure. Since it may have to take its suction from either of the two deaerating heaters, both of its suction valves are kept closed. These valves are motorized, and reduction in the discharge pressure of either one of the motor driven boiler feed pumps opens the corresponding suction valve. After a suitable time interval, obtained by the interposition of a time delay relay in the solenoid control, a valve in the steam supply line corresponding to the unit in which the standby pump is to replace the motor driven pump is opened and the turbine-driven pump comes on the line. As an alternate, the steam valve may be operated by a limit switch controlled by the position of the suction valve.

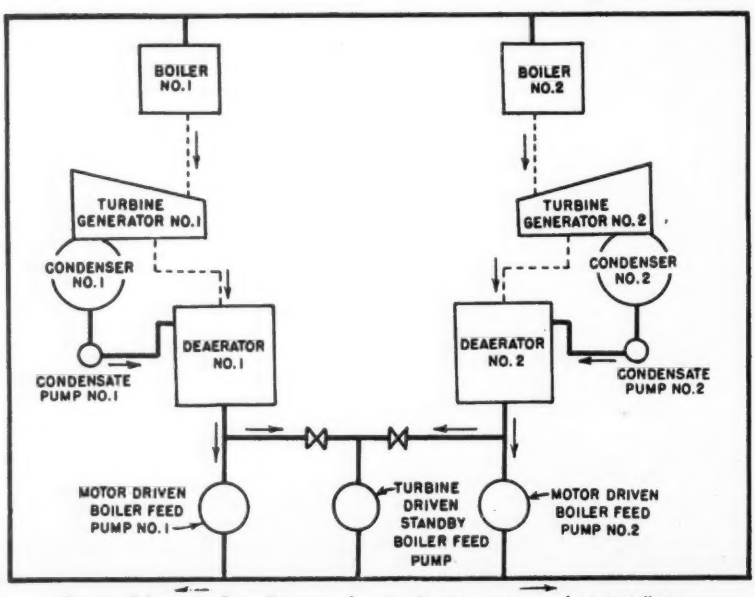


Fig. 1. Schematic flow diagram of a 2-unit steam power plant installation

Why Problems Arise

The various factors, then which may introduce operational problems in such a system are the following:

1) Two boiler feed pumps taking their suction from separate deaerating heaters must operate in parallel at their discharge. The pressure in these heaters and the feedwater temperature at the suction of the individual pumps may be unequal if the two units are operating at different loads.

2) The suction valves of the turbine-driven standby boiler feed pump are normally closed, and they open only a fraction of a minute before this pump is put on the line.

If we consider this last statement, it can be readily seen that if the turbine-driven standby pump is operated at rare intervals, leakage of feedwater through the stuffing boxes

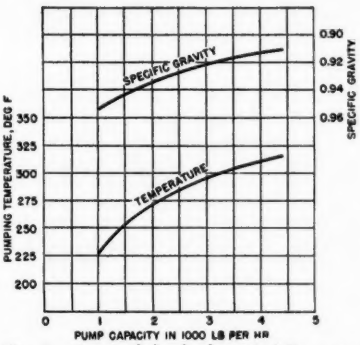


Fig. 2. Assumed load characteristic curve for feed pumps in station discussed in text

may empty the pump casing to an appreciable extent, so that the pump will be partially air-bound. The pump will then seize immediately upon starting up and the resultant damage may be extensive, to say nothing of the unavailability of the pump at the exact moment when it is needed. To prevent such an occurrence, a small by-pass should be installed around one of the suction valves. If a line leads from the pump casing to a point where the pressure is lower than in the dearating heater at the suction, this line will also serve to keep the standby pump warmed up. It is necessary, however, to include a small orifice in this warm-up line, in order to reduce the pressure imposed upon the vessel at its termination when the pump is in operation.

Two Separate Problems

As to the parallel operation of two boiler feed pumps taking their suction from two separate and independent deaerating heaters, two separate problems exist. The first is introduced by the fact that each pump will not necessarily deliver into the discharge header exactly the proportion of feedwater corresponding to the steam flow into its corresponding turbine-generator. This is the case regardless of the fact that the two pumps may be exactly duplicates of each other and have exactly duplicate head-capacity curves. The reason for this unbalanced distribution of load between the two pumps is that the two turbine-generators will not necessarily carry the same load and therefore neither the temperature of the feedwater nor the suction pressure will be the same for both pumps.

Let us examine a typical case for such an installation. It will be assumed that the full load conditions correspond to a flow of 440,000 lb per hr at a temperature of 316 F. The vapor pressure in the feedwater heater, corresponding to this temperature is 70 psi gage (psig). The discharge pressure is 100 psig and the pump is supplied with a net positive suction head of 45 ft, the required total head being 2307 ft. The assumed load characteristic curve is illustrated in Fig. 2 and the performance of the boiler feed pumps in Fig. 3.

Let us now assume that, at a given moment, unit No. 1 operates at a load requiring 400,000 lb per hr while unit No. 2 requires only 200,000 lb per hr. The suction conditions for the two pumps would be as follows:

	Unit 1	Unit 2
Deaerating heater pressure in psig	65.3	28.6
Feedwater temperature in deg F	312	272
Specific Gravity	0.913	0.933
Total Suction Pressure in psig	82.4	46.0
Required Capacity in gpm	875	430

Now if Fig. 3 is used to determine the total heads prevailing at these two capacities, it will be seen that at 875-gpm, boiler feed pump No. 1 will develop 2420 ft, while at 430 gpm, boiler feed pump No. 2 will develop 2670 ft. Converting these figures into pressures using the corresponding specific gravities and adding the prevailing suction pressures, we find that boiler feed pump No. 1 would develop 1039 psig while boiler feed pump No. 2 would develop 1126 psig.

Obviously, then, the two pumps cannot operate in parallel each handling the specified capacity, and a redistribution of load between the two pumps will take place. The determination of the actual capacities must be carried out by trial and error, remembering that regardless of the shifting of the pump capacities, the suction pressures and temperatures remain as shown in the preceding tabulation and do not change with a pump capacity change. Such a trial and error calculation yields the following:

	Unit 1	Unit 2
Actual Capacity in gpm	690	610
Actual Capacity in lb per hr	315,000	285,000
Total head in feet	2570	2610
Net pressure in psi	1015.6	1052
Discharge pressure in psig	1098	1098

It becomes apparent that under such conditions, boiler feed pump No. 1 will take 85,000 lb per hr less from deaerating heater No. 1 than it should, while boiler feed pump No. 2 will draw 85,000 lb per hr more from its heater than it should. While generally an attempt will be made to operate the two turbine-generators more nearly at equal loads, the fact remains that, since this is not always possible, some means must be provided to reestablish equalization of feedwater supply to the two units.

Incidentally, since load distribution between the turbine-generators may vary considerably for any given total station load and since the factors controlling distribution of flow between the two pumps for any given turbine-generator load condition are quite complex, the process of analyzing the ratio of flow by such a trial and error method would be very tedious. It should therefore suffice to establish the fact that pump flow need not necessarily correspond to the steam flow for corresponding units.

How Redistribution Is Effected

The redistribution of feedwater will have to take place at the deaerating heaters, therefore a surge tank must be provided into which excess of feedwater will be delivered from the heater which is not properly evacuated and from which feedwater may be drawn to the heater which would otherwise be starved. The arrangement required is illustrated in Fig. 4, which shows a condensate transfer tank into which is connected the overflow from heaters No. 1 and 2 and from which condensate transfer pumps can deliver feedwater into either heater. This feedwater delivery is controlled by the low-level heater control mechanism in the same manner as the admission of make-up to any deaerating heater.

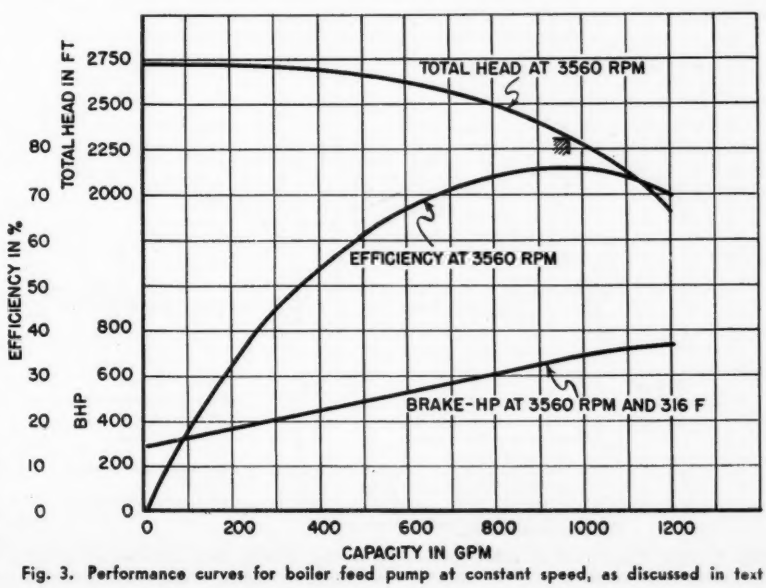


Fig. 3. Performance curves for boiler feed pump at constant speed, as discussed in text

In addition to the unbalance of pump flow and steam flow to the turbine-generator, the paralleling of boiler feed pumps at the discharge but not at their suction introduces a serious problem at all times when the total flow to the boilers is seriously reduced. Generally, in a steam power plant such as described above, the total required steam flow for both turbine-generators may be reduced to somewhere between 100,000 and 150,000 lb per hr during the hours from midnight to 7:00 a.m.

Even when both pumps have absolutely duplicate head-capacity curves, unequal suction pressures (caused by unequal loads on the turbine-generators) will cause unequal discharge pressures at near-zero flow. This difference may actually be sufficient to close the check valve on the pump which has the lower discharge pressure. It is true that the use of recirculating by-pass lines as overheating protection is a standard procedure in modern power plants; and that with either manually or automatically-operated by-passes the danger of operating a pump against shut-off is generally reduced, if not eliminated.

The fact remains that operating two pumps in parallel when a single pump is more than ample to carry the load, is uneconomical and does introduce certain dangers, such as failure of the by-pass to open at the critical moment or failure of the check valve at the discharge of one of the feed pumps to operate.

Two Satisfactory Methods to Solve Problem

The problem of eliminating two-pump operation at these extremely light loads is complicated by the fact that both turbine-generators must remain in operation 24 hr a day. There are, however, two perfectly satisfactory solutions which permit shutting down one of the two motor-driven pumps normally on the line. Up to a certain point, both methods follow the same pattern.

METHOD 1

1. Shut down boiler feed pump No. 2.
2. Shut off stage extraction steam from turbine-generator No. 2 to deaerating heater No. 2.
3. Reroute discharge from condensate pump No. 2 to deaerating heater No. 1.
4. Operate boiler feed pump No. 1 handling the full condensate flow from units No. 1 and 2.

METHOD 2

1. Shut down boiler feed pump No. 2.
2. Shut off stage extraction steam from turbine-generator No. 2 to deaerating heater No. 2.
3. Allow condensate pump No. 2 to discharge into deaerating heater No. 2.
4. Since boiler feed pump No. 2 is shut down, deaerator No. 2 will overflow to the condensate storage tank.
5. The condensate transfer pump will maintain the required level in deaerating heater No. 1 by supplying extra condensate from the condensate storage tank.
6. Operate boiler feed pump No. 1 handling the full condensate flow from units No. 1 and 2.

The choice between these two methods will be guided merely by the relative complexity of re-routing the discharge from the condensate pump of one unit to the deaerator of the other unit. Instead of proceeding from the condensate pump to the deaerator and thence through overflow to the condensate transfer tank, the overflow valve may be made to operate a spillage valve in the condensate pump discharge and the excess condensate is made to by-pass the heater. This does not change the recommended cycle fundamentally.

Third Method in Case of O_2 Contamination

On the other hand, shutting down heater No. 2 might result in some oxygen contamination of the feedwater in the storage space, which might be objectionable. In that event a third method can be used. It would be necessary to provide a connection between the boiler feed by-pass and the condensate transfer tank, suitably valved, to allow flow to take place from the deaerator to the pump and to the storage tank. This flow—in the neighborhood of 10,000 to 20,000 lb per hr would avoid damaging the vent condenser of the deaerator, as an equal amount of condensate would be admitted to the deaerator through the vent condenser, keeping the tubes of the latter cooled to proper temperature. The steps followed in this 3rd method would be as follows:

METHOD 3

1. Shut down boiler feed pump No. 2.
2. Open valve in line from feed pump discharge to condensate transfer tank.
3. Allow No. 2 condensate pump to discharge into line to No. 2 deaerator.

Excess over amount going through stationary No. 2 boiler feed pump will proceed to condensate transfer tank.

4. Transfer pump will maintain required level in No. 1 deaerator by supplying extra condensate from condensate transfer tank.
5. Operate No. 1 pump handling full condensate flow from Units No. 1 and 2.

While eliminating or reducing the extraction from unit No. 2 to its deaerating heater will affect the heat balance of that particular unit unfavorably, it must be remembered that this will take place only at light loads on the unit, where efficient operation is already impaired. In addition, the elimination of one of the two boiler feed pumps during such operation will save considerable horsepower and probably more than compensate losses incidental to non-extracting operation.

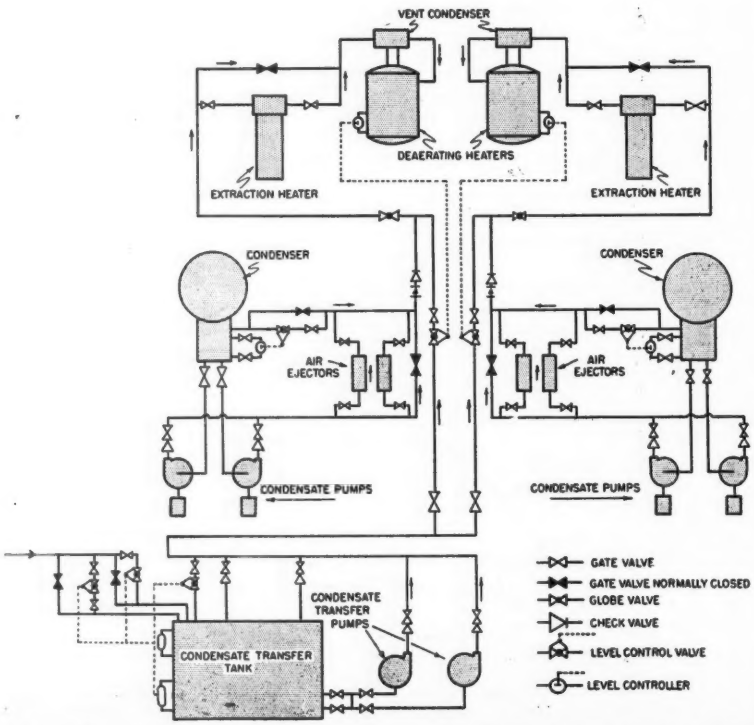


Fig. 4. Flow diagram of an actual generating station, showing how condensate transfer tank and pumps are used to obtain proper redistribution of water in the cycles of two units

ATOMICS

Atomic Power and Fuel Supply

By WARD DAVIDSON

Research Engineer, Consolidated Edison Company of New York, N. Y.

THE subject deserves attention if for no other reason than that if even a small part of the wonders that have been forecast for atomic power are realized, the effects on the use of coal may be considerable.

The problems that must be solved before atomic power can become a reality are first, technical—for until a practical power plant has been built the rest has no reality; and second, economic—for large scale use is hardly conceivable unless atomic power plants can produce power at costs comparable with other means.

The principle of the nuclear reactor is well understood but the problem of operating these reactors at high temperatures necessary for power production involves the selection of proper materials. This in itself is a major task. Few materials are suitable in their pure state for engineering application; the most useful materials are alloys. Every material undergoes some change in its physical properties when subjected to neutron bombardment and radiation of the intensities existing in the nuclear reactor.

Among the possibilities of using various materials ceramics offer opportunities. Ceramics and glass are among the oldest materials man has made use of but they have not been used a great deal for engineering purposes. Only recently have they become of interest to engineers and it is hoped that they may be of use in atomic work.

The nuclear power plant, except for the nuclear reactor in place of the boiler will not differ greatly from present-day plants so far as the generating units are concerned. The turbo-generators and the switchgear will probably be essentially the same as they are now for conventional type plants. Possibly they may be a little larger because of the advantages of large reactors, but that is about all. The real differences will be in the steam generating equipment and in the fuel handling arrangement. Instead of large steam generators, often of impressive height, there will be a much smaller cubic reactor encased in a massive concrete and metal shield and another unit, the steam generator, in a less massive shield. There will be circulating pumps to handle the molten metal heat-transfer fluid or blowers if air is used. In either case these will be large units because of the high velocity at which the fluids will have to be circulated through the constricted passages. The boiler feed pumps will be conventional.

There will be no coal handling equipment and no coal pulverizers: there will be no air preheaters and no dust collectors; there will be no ash sluicing or slag tap system. Instead there will be massive containers probably lead lines, for handling the partially spent charge and removing it to the distant—or nearby—chemical plant; there will be less massive containers for handling the replenishing charge. The control room will be more elaborate than in fuel burning plants, and it will have more interlock and automatic features.

What will this power plant cost? A large, high efficiency coal-burning power plant today will cost something like $190 per kilowatt. Of this, about one half, or, say $100 per kilowatt would be needed for the part that would be needed in a nuclear power plant. There is not an adequate basis for a sound estimate of the other costs, but it may not be unreasonable to assume that they will be at least three times those of the coal-burning station. This gives a figure of $370 per kilowatt for the complete nuclear power station.

The largest item for coal-burning stations is fuel. For the nuclear station the costs could conceivably be far lower, if—and this is an important "if"—ample supplies of uranium ores are found and if it is found possible to reduce greatly present costs of reclaiming and re-processing the partially-spent uranium. (At some later date, thorium may enter the picture as an alternative to uranium.) About the best that one can do now is to say that under present conditions uranium as a fuel for power plants is much more costly than coal, but at some later date it may become somewhat less expensive. As to other operating costs, it seems clear that until there has been extensive experience with nuclear power plants, labor, supervision, maintenance and repair are all likely to be higher than for coal or oil-burning stations.

It must be kept in mind in any attempt to draw conclusions from these figures—and they are at best only the roughest sort of guess—that they have been set up on the assumption that the power plant was a single-purpose development. If, as seems not unlikely, power plants are built as part of a multi-purpose development, then the allocation of common costs, which is to some extent quite arbitrary, may alter the picture.

The above article is an abstract of an article in the October issue of ATOMICS Magazine.

The new ATOMICS represents a greatly expanded service to those who are interested in the theory and application of nuclear energy. It will keep readers abreast of what is happening in the field of atomic power development, in the industrial applications of radioactive isotopes, and in the use of nuclear energy in medicine, biology and agriculture. The October issue, in addition to the article abstracted on this page, contains other material of atomic interest including the fifth installment of the course in Nuclear Power Engineering which started in the June issue.

If you are interested in seeing this new magazine regularly, send in the attached coupon for a free copy. You will be under no obligation for this. ATOMICS will be published monthly, and as has been true of the articles which appeared in the ATOMICS section of Power Generation, the articles will be kept on a practical, understandable level.

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A Laborer's Criticism of Engineering Education

By TELESPHORE L. BOURBONNAIS II

System Relay Man and Control Electrician for Power Plants
Idaho Power Company, Boise, Idaho

THE CURRENT AGITATION for a longer period of training for engineers indicates that the present product is not satisfactory. A more careful adaptation of the instruction to the individual and his future position should be considered as a method of improving the product too.

Officers in the last war who served in a highly technical capacity were exasperated by a somewhat universal opinion held by commanders. These old service men believed that an officer should know the job of every subordinate under him. In our highly technological warfare this was obviously impossible. A similar type of reasoning exists in the engineering profession.

In England the practice of law is divided into two distinct divisions, the solicitors and the barristers. Both professions are in the same field, yet special training is adapted to each and the service they render to the public is different.

In recent years all branches of engineering are applying more and more basic mathematics and physics to their increasingly complicated problems. The engineer's handbook is giving fewer complete answers. The men who solve these very difficult problems are more mathematicians and physicists than they are engineers.

The work of creating engineering projects has the old as well as the new highly theoretical problems. To expect similarly trained men to do both is ridiculous. One works with Kirchoff's Laws and the other with Maxwell's Equations. The tools of one are algebra and trigonometry while those of the other are vector calculus and Bessel functions.

Difference Between Work of Various Individuals

The man who designs a complicated relay or metering instrument is vastly different from the man who correctly groups the equipment on a switchboard. Today both are fundamentally trained the same. The highly theoretical man spends many hours over a drafting board when he should be investigating more thoroughly his mathematics. Similarly the future switchboard designer is struggling with fifth order differential equations when he should be learning to think along lines which will help him to choose which controls the power plant operator uses most frequently and which meters he consults most often so that he can arrange them for best operating efficiency.

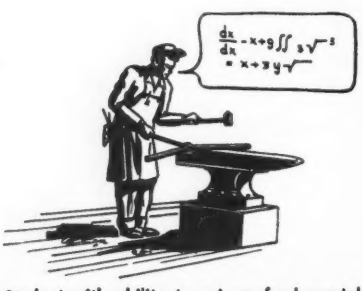
Many problems in industry are incorrectly solved or not solved at all because the highly trained engineer in mathematics and physics is unavailable or not fully appreciated. Many problems now badly handled by self taught electricians and men who "worked their way up" are costing industry many dollars.

Divorce the student with the ability to set up the fundamental equations of long distance transmission lines from hours of hammering and tempering steel. Our democratic way of life provides an opportunity for vast numbers of our population to gain higher education. Only a few of those who wish to be engineers are capable of being masters of mathematics and physics.

Some of the remainder will do the conventional engineering. The rest should be trained to take those lesser jobs such as crew supervisors and just plain operators and technicians.

Let's Be Honest

This last will no doubt provoke adverse comment. But, let us be honest, in almost every engineering office of size there are many men who hold degrees who are parasites on a few fine engineering minds. There are many of us who would be much happier with an electric drill or a pair of "side cutters" in our hands than a table of six place logarithms. Unfortunately along with a degree goes the connotation of a white collar and a desk. If the college graduate doesn't have these things, then he generally feels frustrated.



Student with ability to set up fundamental equations hammering steel

Here is a man, he does not call himself an engineer but he evidently is a pretty good one, who puts his finger upon a very serious spot in our whole social system—the attitude of a college trained person towards the man who works with his hands though not necessarily without his brains.

The question is intimately tied up with a more or less general belief that every mother's son and particularly the college trained father's son is entitled to a college education. As Sidney Harris, the Chicago Daily News' caustic columnist put it recently, this idea is demogogic nonsense and has ruined more happy homes than Demon Rum, fast women or slow horses. Hundreds of BA's and BS's will soon be coming out of college with no jobs waiting for them and will be forced into the service trades, clerical work or manual labor—a bitter comedown from their aspirations. If these men were frankly and honestly being trained and educated to follow one of the skilled trades, they would not only be better satisfied but would be more valuable to society.

Don't be misled by the author's title; he is anything but a laborer. He was graduated as an honor student in electrical engineering from Michigan State College. After completing his academic training he served in the Signal Corps during the war, building very high powered radio stations and establishing an extremely large signal depot on Okinawa. After returning to civilian life he refused several positions as an engineer and went to work as an electrician.

At present, as System Relay Man for the Idaho Power Co., he is responsible for all protective relaying of power plants, major transmission lines and substations of the system. He has been power plant operator in a hydro-Diesel plant, a cable splice and lead wiper and a switchboard wireman. He worked up from the bottom; got into high voltage and got burned, he has climbed unstepped 90 ft poles and tripped a series of major systems off the line and felt the repercussions. And last but not least he has been in labor squabbles of just about every kind. In short, he is well qualified to express his opinion. As Mr. Bourbonnais points out, despite all this, he WAS a laborer when he wrote this article and it is with the hope of using a laborer's perspective in discussing this problem that he hopes to throw light on some of the problems that cause strife in industry. Lack of understanding between the humblest worker and the leaders of industry has been the source of much of our labor trouble.

If the real need of highly trained technicians in the lesser jobs is appreciated then these misfits will find their true place and a new dignity that comes from having done their job well.

Sometimes the "twenty year man" is held in a position of respect that he does not deserve. Often the twenty years of experience is one year's experience twenty times. Much of the information that is supposed to be gained with years can be learned in a class room if the instructor is properly qualified. Of course there is no substitute for real experience, but a man with basic education plus experience will be a very valuable man in twenty years.

Universities Need Not Train Tradesman

Tradesmen are not advocated as a product of the university; however, the school can give a student the foundation upon which a knowledge of the trades can be built. The practice he can get in the field. This type of training will produce a man who will fill a definite need when he moves into a position of leadership. A knowledge of the lower echelons is lacking in some of the successors that are replacing the men who built the industry. Ample proof of this is found in the testimonies of foremen who are vexed by continual nagging by some managements for expense cutting while the management is niggardly in supplying proper tools. The right tool for a job will not only cut labor costs, but it will produce better workmanship which makes a more lasting job. Also, the improper supply and use of small hardware is a factor seldom properly considered. Today alone if all the time wasted by electricians looking for the proper screw to fill a tapped hole were added together it would stagger the industry. Further, much high priced design is thrust upon tradesmen to put into operation which from lack of the workman's point of view costs much more to install, operate and maintain than it should. A keen mind in the lower ranks can give a lot of good constructive advice to the top if he has sufficient prestige to be heard.

Men broadly trained to plug these holes, through which are flowing much profit, could demand higher salaries. Industry would be glad to pay them. These otherwise misfits would find dignity in their jobs. More real peace would reign in the field of battle scarred labor.

The real craftsman likes to do a good job. The ordinary apprentice taught electrician cannot adequately cope with the complicated problems involved in the installation and maintenance of the new complicated designs. There are many mistakes made on the drafting board. A well trained foreman would find many of them and avoid costly mistakes.

The training of these men should be directed to making them actual builders, users of steel and concrete, surveyors who can locate heavy machinery, men who can safely move heavy equipment. Basic conventional engineering plus methods of approach to problems of tool selection, hardware, engineering materials in a much wider scope than is generally covered in the classroom. The curriculum should include the study of labor problems. It should teach leadership of construction crews in particular and men in general.

The laws of economics are important to the student's thinking. He should be taught that engineering like other businesses is generally expected to make a profit.

Breadth in thinking could be increased by giving the student expertly taught seminars in all phases of engineering. Lectures by experts would give him sufficient knowledge of some subjects without forcing him to take courses which would mire his intellect and waste his energies.

What will the unions say about college men in their ranks? The union business agent in the electrical field, where industrial work is encountered, will welcome with open arms the right kind of college men as supervisors. The more and more complicated jobs for which he must supply the labor is a real problem. The regular union man mistrusts the college man until he proves that he is a "right guy," then these hard "narrow backs" welcome him as a brother.

The real craftsman likes to do a good job

Many of us would be happier with an electric drill in our hand

ELECTRICAL HAZARDS WITH METALLIC TAPES, RULES

By WM. N. DAVIS

ONE OF THE most common tools used by electricians, millwrights, and maintenance men is the metal ruler or measuring tape. One of the first things that a workman does when he starts any job is to take measurements but very few workers ever associate a hazard with a simple measuring tape or rule.

Metal rules or measuring tapes should never be used to take measurements near or around electrical equipment. Many accidents have been caused by their use in and about such places as live bus-bars, terminals, switch gear, or other live circuits, and particularly in inaccessible or poorly lighted places. Other accidents are caused by throwing, dropping or pulling metallic fabric tape across live conductors.

A worker may easily be injured by using a metallic rule measuring tape around defective electrical equipment particularly if the workman is using the metallic rule in a wet place. The following examples are some accidents which have occurred and which could have been prevented by observation of proper safety rules.

An electrician was working in the basement of an Ohio power house. The metallic rule he was using to take measurements for bus-bars slipped across two bus-bars sending a high voltage current through his body. He was injured fatally.

A maintenance man for a public utility company in Illinois was measuring the clearance for a trolley wire, using a metal tape. One end of the tape was fastened to the ground, and when the other end which he was holding accidentally came in touch with the trolley wire, he was fatally injured.

A millwright in a Pennsylvania steel mill was measuring a clearance for replacement of an electric motor in a crane. When his metallic rule came in contact with the motor leads, the shock threw him from the crane to the main floor below where he was seriously injured.

If metal rules or tapes must be used near any electrical equipment, the electrical equipment should be de-energized and properly tagged. In the event that the electrical equipment cannot be de-energized and measurements must be taken, the workmen must wear rubber gloves and take all precautions that are usually taken when working on energized equipment.

Questions and Answers

Q & A—THE POWER ENGINEER'S FORUM—HERE'S HOW IT WORKS

YOU HAVE a question about some detail of power plant operation, maintenance, design. You can't find the answer in your own experience nor in the books. So you write in to our editors. If we know the answer, we send it right back to you. (Maybe we don't know the answer either, but we usually know where to get it for you.)

In any case, we publish your question, signed only with your initials. We do not reveal your identity.

Dozens of engineers write in to us, giving their answers. We forward you copies of the replies as soon as we get them.

You, too cooperate with other engineers by answering their published questions in the same way.

Then, so far as space permits, we publish those replies as soon as possible, so that everybody will learn what the others know about the problem. We pay well for all answers published. And those who answer get credit for knowing.

Simple, isn't it? And effective? Just ask the power engineer who has tried it!

Engineers who take the trouble to answer your question would appreciate some information from you, transmitted through the Q & A editor, on how their answers helped solve your problem. In doing this, indicate whether or not your comments could be published for the benefit of all readers.

Question No. 450

WHAT CAUSES BURNER TROUBLE AND HIGH DRAFT IN THESE BOILERS?

IN OPERATING an arrangement of boilers as shown in the accompanying drawing, we observed that on boilers No. 9 and 10, when the dampers are closed so that the draft is 0.08 in. to 0.09 in. as it should be at full load, we get a vibration and the burners back-fire and go out.

The boilers are fired with natural gas, and using register type burners.

So far we have failed to find the cause. Can you assist us in finding our trouble by telling us possible causes and various points to investigate?

The lowest we can reduce the draft on boilers No. 9 and 10 is 0.25 in. of water, whereas all the other boilers are carrying 0.08 in. to 0.09 in. of water. The CO_2 reading on these two boilers is also very low because of the high draft we have to carry.

The boilers are fired from the side and have a large stack and breeching because they are equipped with Dutch ovens for burning bagasse.

Belle Rose, La. C.C.S.

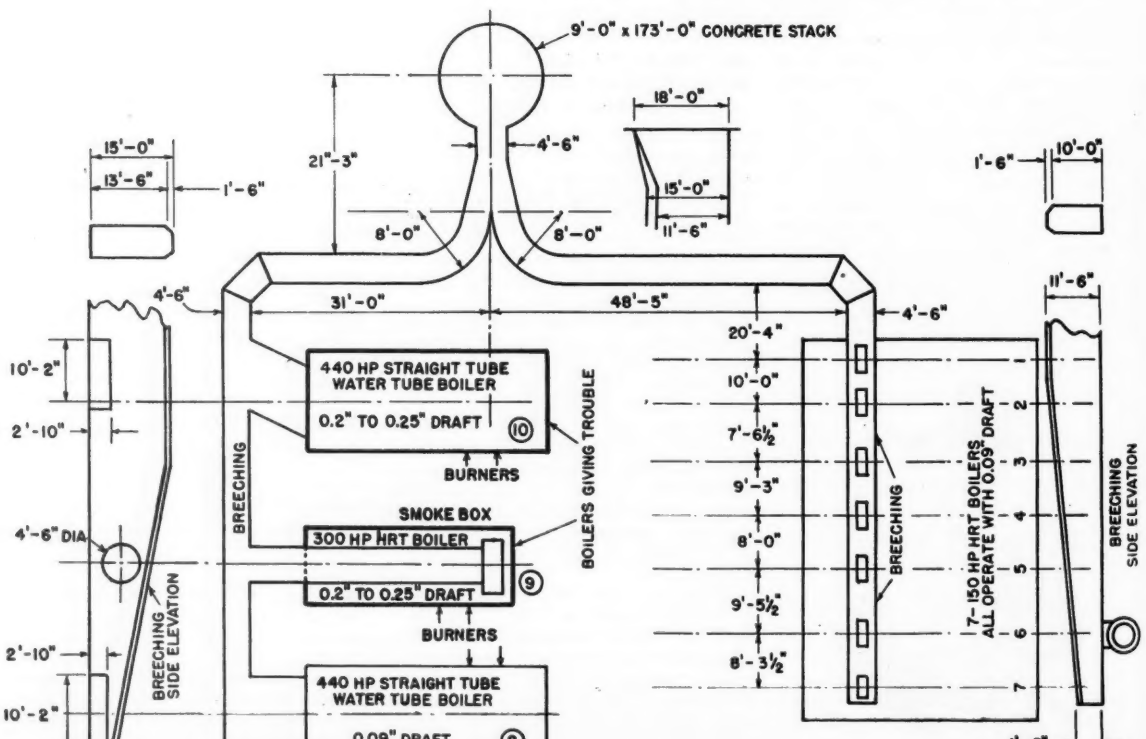
Answer No. 444

CAN HE USE A CADMIUM STORAGE BATTERY IN A POWER PLANT?

THIS QUESTION was asked by W.J.S. in the July issue. He had seen an article on the nickel-cadmium storage battery, and wanted more information on it because his power plant is considering installation of a storage battery.

This nickel-cadmium storage battery is reported to have been developed in Europe and used there successfully for many years.

At any rate, C. O. von Dannenberg commented on it in the September issue, stating that its performance and economics, especially for power station use as a control battery or other d-c source, are still to be definitely determined. He commented on the good performance of the conventional lead-type storage battery in so many power plants, pointing out that his company has many installations over 15 years old and one of over 25 years. Care and maintenance



Plan of boiler and breeching arrangements by C.C.S., boilers Nos. 9 and 10 have burner trouble, high draft and low CO_2

nance, temperature conditions, and other factors, he said, are important in securing best results from lead batteries and similar factors must be considered with the nickel-cadmium battery.

Incidentally, the name and address of the manufacturer of the nickel-cadmium batttery were not given quite correctly in the September issue.

Here, by permission, is some important information about an installation of the nickel-cadmium battery recently made in a well-known power station.

A Power Station Installation

THE NICKEL-CADMIUM battery is being manufactured by the Nickel Cadmium Battery Corp. in Easthampton, Massachusetts. The sole distributor is C. Tennant Sons & Co., Empire State Bldg., New York 1, N. Y.

In the recently-completed 30,000-kw extension to the English Station of The United Illuminating Co., New Haven, Conn., an installation of this type battery is used as an emergency supply of d-c and is arranged to float on the line. The installation consists of 32 batteries of 3 cells each with a total capacity of 300 amp hr at 125 v.

The new 30,000-kw extension has a highly-centralized control system and this type of battery was selected for this control system.

New Haven, Conn. J. A. LINK
Westcott and Mapes, Inc.

In a subsequent letter, Mr. Link adds:

"Regarding Mr. von Dannenberg's comment in the September issue, I might add that the experience of The United Illuminating Co. with the lead-acid type battery has also been good. They have one installation that has been in service since 1936."

Finally, it is reported that a representative of a nickel-cadmium battery manufactured in Sweden is Nife, Inc., 165 Broadway, New York 7, New York.

Comments by Freyberg

W.J.S. SHOULD be able to get all the information he requires by writing to the Nickel-Cadmium Battery Corp. This company has been supplying automobile type batteries for some time and can furnish combinations for power station standby service. The units are expensive but much of the first cost can be written off by their reliability and infrequency of recharging.

Along this latter line an interesting anecdote is often told about Mr. Berg who is the son of the inventor of this type battery, and who is associated with the concern above. It seems that before World War II, Mr. Berg was in this country trying to interest capital in the battery. Something less than successful, he was caught here by the war. His car was equipped with one of his batteries and when he put it in a garage for the duration of the war he made no special provisions for its care. Later, he wrote the garage man requesting that his car be sold for what it would bring, and it was.

A couple of years ago Mr. Berg returned to this country to carry out his original purpose. Needing a demonstration unit he contacted his garage for information as to the disposal of his pre-war car. The records showed the new owner's name, but a hood-raising disclosed only a standard battery. Back at the garage, the mechanic was questioned and he remembered throwing the battery on the junk heap not far from the garage. By digging through the heap they located it, put it in Mr. Berg's present car in place of the standard battery. He stepped on the starter and drove away, much to the amazement of the assembled group. Three or four years on the dump!

It is claimed that some of the European units are good after 20 years of standby service. They are supposed to lose approximately 15 per cent of charge in about two years. They are usually combined in 1.2 volt cells.

Pleasantville, N. Y. R. H. FREYBERG

Answer No. 446

WHY IS THIS CIRCUIT GROUNDED THROUGH A FUSE?

JUDGING FROM the details given, the reply must actually come from the person or authority who decided to install a fuse for some specific reason. So far as the writer knows, there is no requirement for any application where a fuse is called for in a ground connection. There are situations where some type of circuit breaker may be placed in a ground connection, which can be arranged to open automatically in the

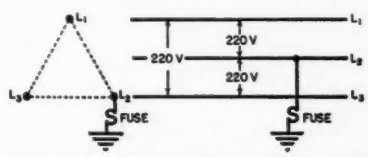
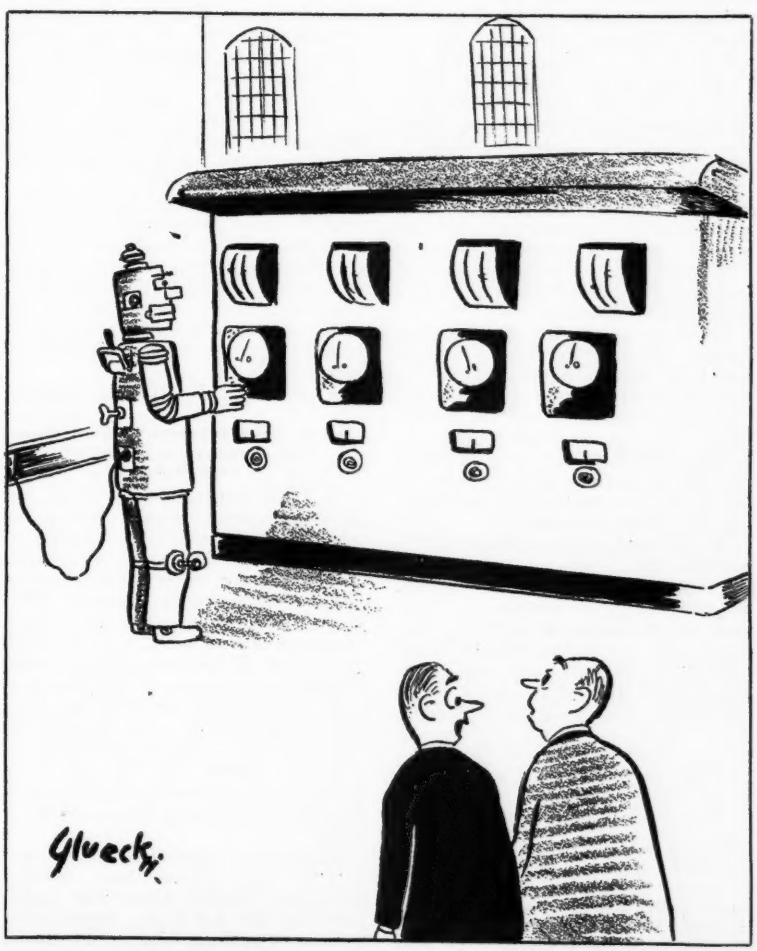


Fig. 1. Conditions in W. T. C.'s system at present, as von Dannenberg interprets them



"Everything is automatic—right up to the Chief Engineer"

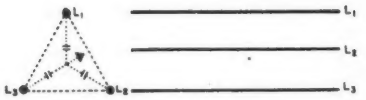


Fig. 2. Another circuit condition in which the voltage would be different from Fig. 1

event of a ground fault resulting in a flow of current of preassumed value, this would, of course, result in an ungrounded system so long as the grounding breaker was open. It is necessary, if operating grounded was a normal condition, to have some type of indication to show the non-grounded operation when this occurs.

Figure 1 indicates the conditions as interpreted by the writer and it follows that the voltmeter readings from L1 to L3 to ground will remain at a nominal value of 220 v so long as the connection of L2 to ground through the fuse remains intact, expressing it in another way, the voltage of L1 or L3 to ground remains constant and the respective insulation strain of these conductors will not vary.

If, however, we have circuit conditions like Fig. 2, the whole situation is changed and the different voltages of L1, L2 and L3 to ground should theoretically be 220 $\div \sqrt{3}$ or 127.02 v. But what they actually will be when tests are made with a voltmeter may be quite different and may, indeed, vary from the theoretical value of 127.02 v given, to zero or even to full 220 v to ground depending upon the relative capacity or insulation value to ground. Fig. 3 indicates conditions where voltmeter readings E12 and E32 show full voltage to ground, which is a possible condition for any ungrounded system.

The foregoing indicates what may happen in an ungrounded system and how the strain on the insulation may vary through a wide range. This is an important matter for the higher voltages and for values exceeding 60,000 v between conductors enables advantage to be taken, resulting in the lower costs of "grading" insulation to ground.

At the operating voltage given, namely 220 v between L1, L2 and L3 there seems no definite reason for grounding one conductor at all, and particularly through a fuse unless the particular authority has a desire to operate that way. It is clear that a ground on either L1 or L3 should cause the fuse between L2 and ground to "blow" if conditions are suitable but when the fuse does blow the presence of the ground should at once be made known.

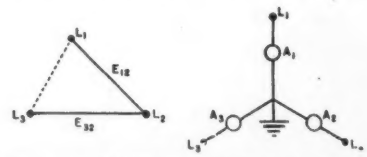


Fig. 3. (Left) Diagram showing full voltage to ground on any ungrounded system. Fig. 4. (Right) Simple arrangement of three 220-v ground lamps, A1, A2, A3

A simple arrangement of three 220 v lamps, as in Fig. 4, will indicate at once whether a ground or partial ground exists on a 3-phase ungrounded system by the relative brightness of lamps A1, A2 and A3, the dimmest one being connected to the faulted conductor. This is, of course, readily supplemented by some audible signal device and in actual experience is a most satisfactory method. As a final comment DO NOT GROUND THROUGH A FUSE.

Brooklyn, N. Y. C. O. VON DANNENBERG

Comment by Jeffries

PRIMARY REASON for grounding the type of circuit described is always to protect the installation and personnel from an abnormal potential resulting from a cross or breakdown of any kind. The fuse completely defeats this purpose, for it will not maintain the ground just when it becomes essential.

The case in question appears to be an attempt to "have one's cake and eat it too." If the circuit was solidly grounded (no fuse), and another ground occurred, it should cause some overload device to disconnect the circuit; in short, to shut the plant down. However, with the fuse as described, another ground would blow the fuse and leave the plant in operation until it was convenient to locate and clear the ground.

It is very likely that, in connection with the fuse, some form of ground detector was also installed in a manner that would indicate that the fuse was intact and the other two lines clear of grounds. The foregoing assumes that the circuit is not protected by any scheme of ground relaying.

Morristown, N. J. RUSSELL JEFFRIES

Install Ground Lamps, Remove Fuse with Appropriate Ceremony, says Forbes

W.T.C.'s query regarding his grounded delta system brings to mind a similar situation, which existed for years in one of our plants.

We had, for those days, a large 230-v, 3-phase delta system (4000 kva) the secondary bus for which consisted of four 8-in. by ¼-in. bars per phase. It is interesting to note in passing that, even though this bus was installed back in 1921, the four bars of each phase were mounted in the form of a hollow rectangle to minimize losses. Special bus supports were designed and built and inter-phase supports were also provided.

When this installation was completed, one phase was solidly grounded. Nobody could ever recall just why this was done. Apparently a-c power systems of any form were naturally supposed to be grounded and, since our system had no neutral, one phase was tied down.

Now it is obvious, of course, that with one phase grounded, a ground fault on either of the other two phases forms a short circuit. With a good solid ground fault on a system as large as ours, the ground current was terrific and considerable damage often resulted before the fault was cleared either by the tripping of a branch air circuit breaker or, as frequently happened, the tripping of the primary oil circuit breaker. Taps from the main bus consisted of two 6-in. by ¼-in. bars per phase and we actually burned these off more than once; in fact, on one occasion, twice in 10 min.

The installation was originally made to supply a battery of single-phase electric furnaces all of which were equipped with air circuit breakers and metering current transformers. The furnaces were occasionally shifted from phase to phase to maintain a reasonably balanced condition so that the ammeters were liable to be in either the grounded or ungrounded phases at various times.

When ground faults occurred on the grounded phase, some rather freak current distribution took place. Furnaces would suddenly show half load or less and yet production would remain normal. This was very mysterious to the operators and they would refuse to operate such a furnace. The qualms of the furnace operators, however, did not bother us nearly as much as the damage that too often resulted from ground faults. It didn't do any good to explain that the grounded delta invited trouble, because the old timers just knew that power systems had to be grounded.

Prior to this 230-v installation, all our power had been direct current, supplied by turbine-generators. Plant maintenance men fought to keep the d-c system clear of grounds and yet they willingly accepted and maintained what amounted to a permanent fault on their a-c system.

Later, when 440-v delta systems were installed, no system grounds were provided. Ground lamps were installed, instead, to indicate accidental grounds and each of these faults was run down and eliminated before another might occur on another phase. The idea on the 440-v systems was that we were endeavoring to prevent the type of damage which the 230-v system actually invited.

After years of successful operating experience with the ungrounded 440-v systems, it was still extremely difficult to persuade the old-timers that a grounded phase on the 220-v system caused, rather than prevented, trouble.

The grounded delta system permits no supervision and the grounded phase itself could also be accidentally grounded in half a dozen places without showing it.

Two out of three accidental grounds become "shorts".

My advice to W.T.C. is to take the following three steps in the order shown:

1. Make sure all his 220-v equipment is grounded in accordance with good practice.

2. Install 220-v, 3-phase ground lamps.

3. With proper ceremony befitting the occasion, permanently remove the fuse in the ground connection.

When this has been done, W.C.T.'s questions are automatically eliminated. They don't require answers because they no longer exist. He will then be able to supervise properly all three phases of his system, eliminating accidental grounds as they occur and before they have a chance to cause the trouble which is inherent in his present system.

Bridgeport, Conn. B. G. FORBES

Answer No. 449

WHAT OPERATING DATA SHOULD BE LOGGED FOR A 1250-KW CONDENSING TURBINE GENERATOR?

Log Sheets from Miller

HERE ARE COPIES of the daily switchboard and turbine log sheets that are used in the plant where I am employed.

These forms have worked out very well for us. As you can see, they contain only spaces for readings that would indicate any unusual operating conditions.

Our No. 3 and No. 4 turbines are similar to the one R.B.D. mentions in the question; and the readings we take would, in all probability, be suitable to his turbine also. He may, however, want to add a space for his extraction pressure and temperature

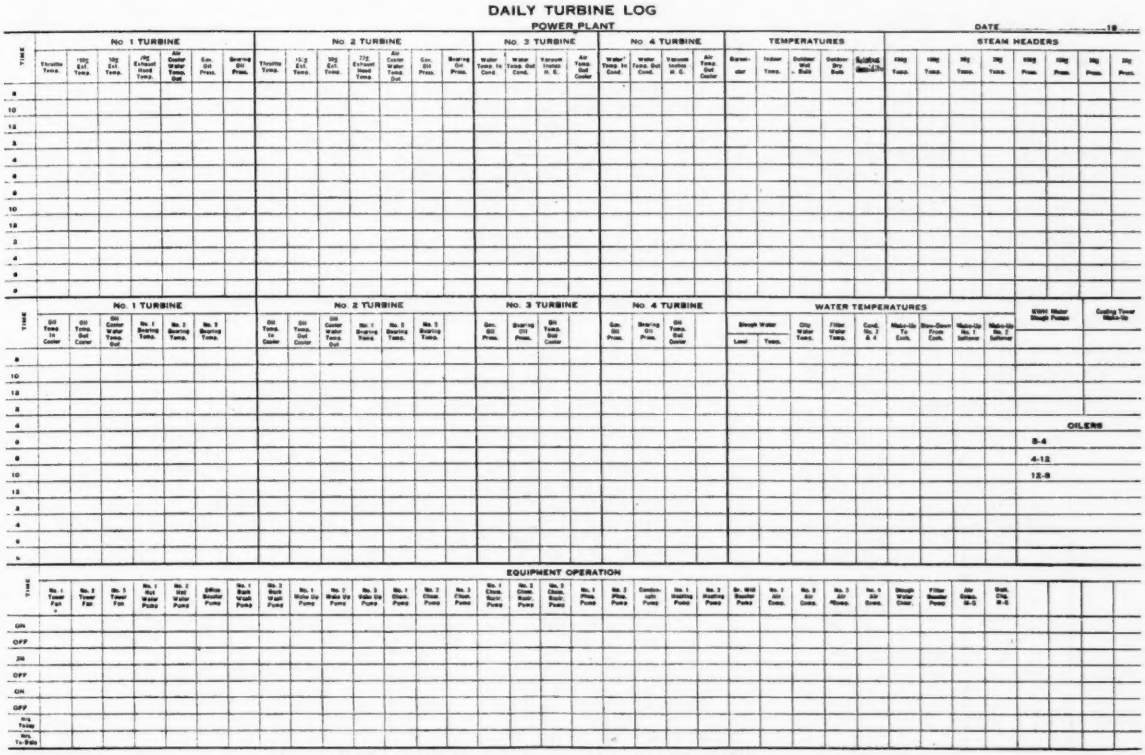


Fig. 1. Daily turbine log sheet as used in Louis B. Miller's power plant

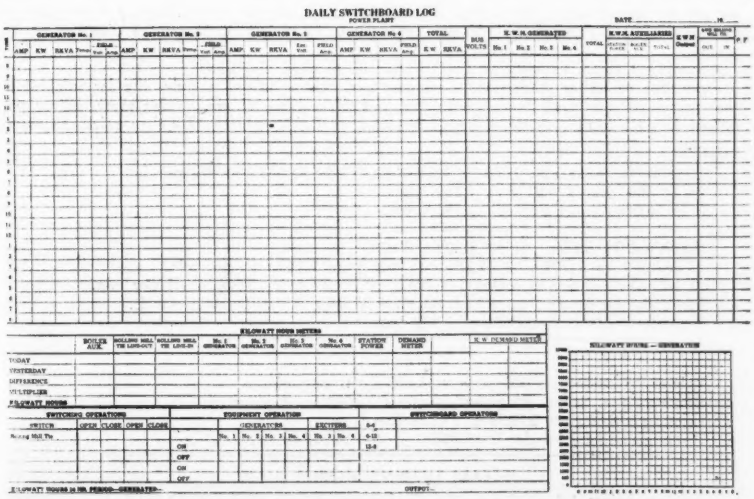


Fig. 2. Daily switchboard log sheet as used in Louis B. Miller's power plant

and maybe a space for the pressure in the turbines' first stages.

Many engineers will send in log sheets, so R.B.D. will probably end up with a better one than any of us. He will find no two alike and will probably use only the best ideas from all of them. It would be interesting to see what his final choice looks like.

Alton, Ill. LOUIS B. MILLER

Editor's Note: — Because of severe space limitations, we are unable to present these log sheets in their full size which is 10 by 16 in. In these reproductions, therefore, you will have to read the smallest print with a magnifying glass. The logs can be enlarged by photostating; if you cannot do this conveniently, ask the Q & A editor, who will photostat them if there are requests enough. We're sorry we have to make them so small; our standard editorial practice is to make lettering on all cuts come out not less than 1/20 in. high. But obviously that is not possible here, even on the full-sized log sheets.

Basic Power Plant FIGURING

A Review for Old-Timers
A Must for Young-Timers

By **WILLIAM H. ENGELMAN,**
Mechanical Engineer,
Department of Water & Light,
City of Cleveland, Ohio

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Typical Power Plant Problems involving flow of steam in pipes using data from Table A, data on Schedule 40 Pipe, August issue, and Table B, Schedule 80 Pipe, September issue. Also, at the end of the second problem, you are to find coal consumption and fan capacity for a 4 boiler plant

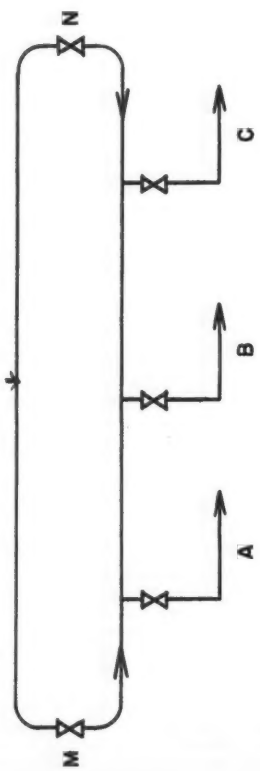


Fig. 1. Diagram of 18 in. steam heater supplying 300 psi, 620 F steam to three turbine generators

Turbine No.	A	B	C
Ratio, steam consumed	0.90	1.55	2.05
Cu ft steam per min	4,970	8,561	11,322
Sched, 40 pipe, in.	10	12	14
Steam Velocity, fpm	9,070	11,014	12,045
Steam, lb per hr	145,392	250,455	331,214
Steam, lb per khr	20	16	12
KW generated	7,270	15,653	27,601

Problem 1:—An 18-in. steam header, Schedule 40 pipe, Fig. 1 carries steam of 300 psia and 620 F total temp. at a velocity of 16,000 fpm. It supplies 3 turbines No. A, B, & C which have a steam consumption in the ratio of 0.90 : 1.55 : 2.05. Find size of pipe from main header to turbines allowing a velocity of 1,000 fpm per inch diameter. What is the kilowatt capacity of each turbine if the steam rate is 20, 16, and 12 lb per kwhr respectively?

Solution:—

Volume of 18 in. OD pipe is 1.5533 cu ft per ft (see pipe data sh.)
Volume of steam per min, is $1.5533 \times 16{,}000 = 24{,}853$ cu ft.
Adding the ratios: $0.90 + 1.55 + 2.05 = 4.5$

Turbine A uses $\frac{24{,}853 \times 0.9}{4.5} = 4{,}970$ cu ft per min.

Assuming a 10-in. pipe; volume is 0.5475 cu ft per ft.
Velocity is $4{,}970 \div 0.5475 = \underline{9{,}070 \text{ fpm}}$. This size is O.K.

Turbine B uses $\frac{24{,}853 \times 1.55}{4.5} = 8{,}561$ cu ft per min.

Assuming a 12-in. pipe; volume is 0.7773 cu ft per ft.
Velocity is $8{,}651 \div 0.7773 = \underline{11{,}014 \text{ fpm}}$. This size is O.K.

Turbine C uses $\frac{24{,}853 \times 2.05}{4.5} = 11{,}322$ cu ft per min.

Assuming a 14 in. OD pipe; volume is 0.940 cu ft per ft.
Velocity is $11{,}322 \div 0.940 = \underline{12{,}045 \text{ fpm}}$. This size is O.K.

Calculating the steam consumption or steam supply to each unit, we have
v_g at 300 psia and 620 F is 2.051 cu ft per lb.

Turbine A $= \frac{4{,}970 \times 60}{2.051} = 145{,}392$ lb per hr; at 20 lb per kwhr is $\underline{7{,}270 \text{ KW}}$.

Turbine B $= \frac{8{,}561 \times 60}{2.051} = 250{,}455$ lb per hr; at 16 lb per kwhr is $\underline{15{,}653 \text{ KW}}$.

Turbine C $= \frac{11{,}322 \times 60}{2.051} = 331{,}214$ lb per hr; at 12 lb per kwhr is $\underline{27{,}601 \text{ KW}}$.

Note: Use Keenan & Keyes Steam Tables, 1936 edition.
Use pipe data sheet for volume in cu ft per foot of pipe.

Flow of steam in pipes based on an allowable velocity.

Problem 2:—Four boilers at 1000 hp each are operating at 250 per cent rating. The steam pressure is 400 psia at 750 F total temperature. The feedwater enters the boiler at 212 F. The boiler steam lines feed into a steam header which supplies 3 steam turbines A, B, and C in the ratio of 1.0 : 1.3 : 1.6. The steam rates are 12.0, 10.5, and 9.0 lb per kw per hr respectively. The boilers are operating at 78 per cent efficiency when burning coal of 13,000 Btu per lb with 60 per cent excess air. Figure 2 shows the diagram of the plant.

Assuming a steam velocity of 1.000 ft per in. of pipe dia, find:

Pipe sizes of boiler leads, steam header, and steam turbine supply, the kw generated, the pounds of coal fired for a 24 hr day, and the volume of air the fan must deliver per minute to each boiler. Answers are summarized on Fig. 2. Here's how they calculate them:

Solution:—

Each boiler generates $1000 \times 2.5 \times 33{,}475$ or 83,687,500 Btu per hr.
H at 400 psia & 750 F is 1,389.7 Btu.
h in feedwater at 212 is 180.1 Btu.

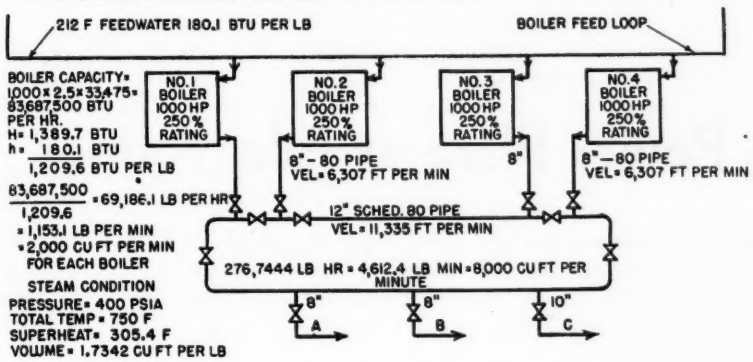
Furnished by boiler = 1,209.6 Btu.
$83{,}687{,}500 \div 1{,}209.6 = 69{,}186.1$ lb per hr or 1,153.1 lb per min.
at 1.7342 cu ft per lb makes 119,983.5 cu ft per hr or 2,000 cu ft per min.
For boiler leads use 8-in. sched. 80 pipe; volume is 0.3171 cu ft per ft.
Velocity is $2{,}000 \div 0.3171$ or 6,307 fpm.

STEAM LOOP

Volume of steam is $2{,}000 \times 4$ or 8,000 cu ft per minute.
Assume 12-in. Sched. 80 pipe; volume is 0.7058 cu ft per ft.
Velocity is $8{,}000 \div 0.7058$ or 11,335 fpm.
Steam passed by header is $69{,}186.1 \times 4 = 276{,}744.4$ lb per hr.

STEAM TURBINE SUPPLY LINES

Adding ratios: $1.0 + 1.3 + 1.6 = 3.9$ and $8{,}000 \div 3.9 = 2{,}051.3$ (a constant).
for cubic feet per minute also $276{,}744.4 \div 3.9 = 70{,}960$ lb per hr.; a constant.


LB STEAM GENERATED ARE BASED ON BTU FURNISHED BY BOILER (EXCLUSIVE OF BTU IN FEED-WATER) WHICH DETERMINES THE CAPACITY OF THE TURBINES.
212 F FEEDWATER 180.1 BTU PER LB
BOILER FEED LOOP
BOILER CAPACITY= 1000 x 2.5 x 33,475 = 83,687,500 BTU PER HR.
H= 1,389.7 BTU
h= 180.1 BTU
1,209.6 BTU PER LB
83,687,500 / 1,209.6 = 69,186.1 LB PER HR
= 1,153.1 LB PER MIN
= 2,000 CU FT PER MIN FOR EACH BOILER
NO.1 BOILER 1000 HP 250% RATING
NO.2 BOILER 1000 HP 250% RATING
NO.3 BOILER 1000 HP 250% RATING
NO.4 BOILER 1000 HP 250% RATING
8"- 80 PIPE VEL= 6,307 FT PER MIN
8"
8"—80 PIPE VEL= 6,307 FT PER MIN
12" SCHED. 80 PIPE VEL= 11,335 FT PER MIN
276,7444 LB HR = 4,612.4 LB MIN = 8,000 CU FT PER MINUTE
STEAM CONDITION
PRESSURE= 400 PSIA
TOTAL TEMP = 750 F
SUPERHEAT= 305.4 F
VOLUME= 1.7342 CU FT PER LB
8" A
8" B
10" C

TURBINE NO	A	B	C
LB STEAM PER KW HR	12.0	10.5	9.0
RATIO OF TOTAL STEAM CONSUMED	1.0 (.2564)	1.3 (.3333)	1.6 (.4103)
LB STEAM USED PER HR	70,960	92,248	113,536
LB STEAM USED PER MIN	1,182.7	1,537.5	1,892.3
CU FT STEAM PER MIN (V= 1.7342)	2,051.3	2,666.7	3,282.0
PIPE SIZE (SCHED. 80)	8"	8"	10"
STEAM VELOCITY FT PER MIN	6,469	8,410	6,578
KW GENERATED	5,913.3	8,785.5	12,615

Fig. 2. Flow diagram for Prob. 2, complete power plant; values calculated in text

Turbine A; 2,051.3 × 1.0 = 2,051.3 cu ft.
Using 8-in. Sched. 80 pipe; 2,051.3 ÷ 0.3171 = 6,469 ft per min velocity.
Kw generated is 70,960 × 1.0 ÷ 12.0 = 5,913.3. Answer
Turbine B; 2,051.3 × 1.3 = 2,666.7 cu ft.
Using 8-in. Sched. 80 pipe, 2,666.7 ÷ 0.3171 = 8,410 ft per min. velocity.
Kw. generated is 70,960 × 1.3 ÷ 10.5 = 8785.5. Answer
Turbine C; 2,051.3 × 1.6 = 3,282 cu ft.
Using 8-in. Sched. 80 pipe; 3,282 ÷ 0.3171 = 10,350 ft per min. velocity.
Using 10-in. Sched. 80 pipe; 3,282 ÷ 0.4989 = 6,578 ft per min. velocity.
Kw generated is 70,960 × 1.6 ÷ 9.0 = 12,615. Answer

COAL CONSUMPTION IN 24 HOURS

With 13,000 Btu per lb in the coal, and a boiler efficiency of 78 per cent,

$$\frac{83,687,500 \times 4}{13,000 \times 0.78} \times 24 = 792.312 \text{ lb. per 24 hr or } 396.16 \text{ tons per day.}$$

FAN CAPACITY REQUIRED FOR EACH BOILER

From Fan Data Sheet No. 10, 60 per cent excess air and at 78 per cent boiler efficiency. boiler requires 11.68 cfm boiler hp at 70 F.
Total volume is 11.68 × 2,500 = 29,200 cfm.

Table showing air requirements per boiler horsepower at various efficiences

Assuming 70 F boiler room temperature and the density of air as 0.075 lb per cu ft, the theoretical cu ft of air per min is:

$$\frac{\text{Boiler hp} \times 25.61}{\text{Eff'y} \times 0.075 \times 60} = \frac{5.69 \text{ boiler hp}}{\text{Eff'y.}} \quad (100\% \text{ Air})$$

Per Cent Excess Air	Factor for Total Air	Per Cent CO_2	Efficiency, Per cent					
			60.0	65.0	70.0	75.0	80.0	85.0
			Cubic Feet of Air per Boiler HP per Minute					
0	1.0	18.57	9.48	8.75	8.13	7.59	7.11	6.70
10	1.1	16.84	10.43	9.63	8.94	8.35	7.82	7.37
20	1.2	15.42	11.38	10.50	9.76	9.10	8.53	8.04
30	1.3	14.20	12.32	11.38	10.57	9.86	9.25	8.71
40	1.4	13.16	13.27	12.26	11.38	10.62	9.96	9.38
50	1.5	12.28	14.22	13.13	12.20	11.38	10.67	10.05
60	1.6	11.49	15.17	14.01	13.01	12.14	11.38	10.72
70	1.7	10.80	16.12	14.88	13.82	12.90	12.09	11.39
80	1.8	10.19	17.06	15.76	14.63	13.66	12.80	12.06
90	1.9	9.65	18.01	16.63	15.45	14.42	13.51	12.73
100	2.0	9.16	18.96	17.51	16.26	15.17	14.22	13.40
110	2.1	8.72	19.91	18.38	17.07	15.93	14.94	14.07
120	2.2	8.32	20.86	19.26	17.89	16.69	15.65	14.74
130	2.3	7.95	21.80	20.13	18.70	17.45	16.36	15.41
140	2.4	7.62	22.75	21.01	19.51	18.21	17.07	16.08

Example: A 1,000-hp boiler operates at 150 per cent rating with an efficiency of 75 per cent and 60 per cent excess air. What is the air requirement in cubic feet per minute?

1,000 × 1.5 × 12.14
is 18,210 cu ft per min. Answer

Example: How many cubic feet of air per minute must a forced draft fan deliver to two 500 hp boilers operating at 250 per cent of rating with 70 per cent excess air and 70 per cent efficiency?

2 × 500 × 2.5 × 13.82
is 34,550 cu ft per min. Answer

The third column gives the per cent CO_2 for efficient combustion of bituminous coal. For any given coal analysis there is always a definite relation between the per cent CO_2 and the excess air in the dry products of combustion.

In the first example the CO_2 with 60 per cent excess air is 11.49 per cent.

In the 2nd example the CO_2 with 70 per cent excess air is 10.80 per cent.

The CO_2 values are very close for semi-bituminous, subbituminous, and bituminous coals.

Here is the basis on which the Fan table is calculated.

Forced Draft—Air Requirements

From MacNaughton, 3rd edition, page 184, or other books the weight of air theoretically required for combustion per pound of coal, called W_a is:

$$11.6\ C + 34.8\ (H - 0/8) + 4.35\ S$$

Using this formula for widely different fuels, it was found that the theoretical weight of air for complete combustion of one pound of the different fuels is practically a constant, equal to 7.65 lb per 10,000 Btu in the fuel.

Using this constant, the theoretical weight of air supply may be calculated directly from the Btu content of the fuel as follows:

Theoretical pounds of air equals

$$\frac{\text{Btu} \times 7.65}{10,000}$$

To calculate the air required under average conditions for forced draft in connection with boilers,

Pounds of fuel burned per hour is

$$\frac{\text{Blr hp} \times 34.5 \times 970.3}{\text{Eff'y} \times \text{Btu}}$$

By combining these two formulas it is found that the theoretical weight of air per hour =

$$\frac{\text{Blr hp} \times 34.5 \times 970.3 \times \text{Btu} \times 7.65}{\text{Eff'y.} \times \text{Btu} \times 10,000} = \frac{\text{Blr hp} \times 25.61}{\text{Eff'y}}$$

Note: the Btu cancel out.

With an average boiler room temperature of around 70 F, which gives the density of air as 0.075 lb per cu ft, we have theoretical cubic feet of air per minute =

$$\frac{\text{Blr hp} \times 25.61}{\text{Eff'y.} \times 0.075 \times 60} = \frac{5.69 \text{ Blr hp}}{\text{Eff'y.}} \quad (100\% \text{ air})$$

With 40 per cent excess air or 140 per cent total air, the factor 1.4 is applied, thus:

$$\frac{1.4 \times 5.69 \times \text{Blr hp}}{\text{Eff'y.}} = \frac{7.97 \text{ Blr hp}}{\text{Eff'y.}}$$

and so on with any amount of excess air expressed in per cent.

The above formula does not require knowledge of the Btu content of the coal, yet it is sufficiently accurate for all forced draft calculations for boilers.

DESIGN

New 3000-Kw Power Plant at Iola, Kansas

Modern plant with 3000-kw turbogenerator and two 40,000 lb per hr, 400 psi 750 F boilers replaces old plant at Iola, Kansas. This plant is expected to operate with a heat rate of about 16,000 Btu per kwhr—twenty per cent below that of best unit in existing plant

By EDGAR A. COOPER, Brink, Dunwoody and Cooper, Iola, Kansas

NUMEROUS SMALL towns entered the recent war period with municipal electric plants which were barely adequate for the demands of 1940. Almost all of them came out of the war period with critical overloads, with a certainty of still greater demand, and with no new equipment even on order.

Iola, Kansas, 7300 population, was typical of those municipalities. How the problem is being met may be of interest to similar communities.

A complete study of the situation was made in 1946. At that time the plant peak load was 1500 kw. But a survey of new installations planned by customers of the system revealed that a peak load of 2500 kw within ten years was a certainty, 3200 a very real possibility.

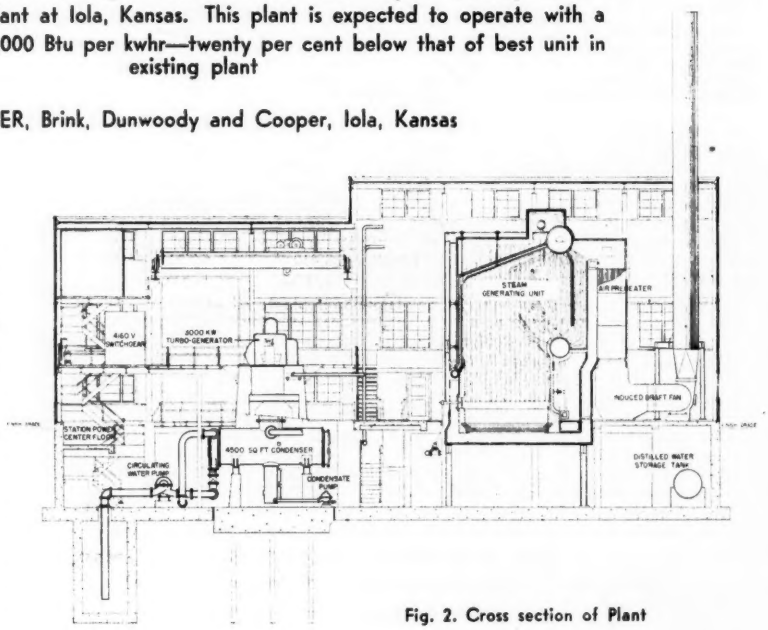


Fig. 2. Cross section of Plant

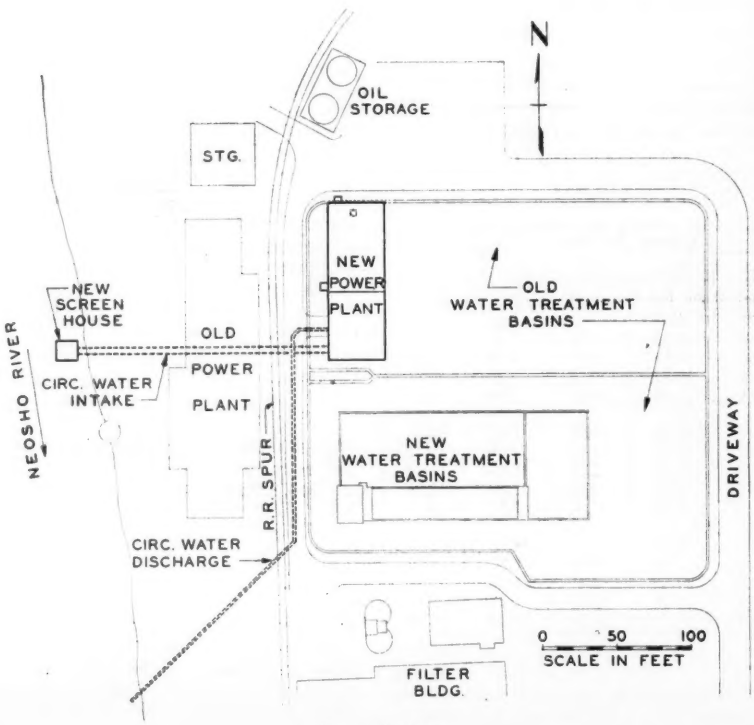


Fig. 1. Plot Plan

The existing plant consisted of an old wooden roofed, brick building equipped with six boilers and three turbo-generators. Two of the turbo-generators, rated 1000 kw and 1500 kw respectively operated on 150 psi saturated steam, and one rated 1500 kw operated on 400 psi, 700 F steam. The boiler plant consisted of five old Heine water tube 150 psi boilers, one of which was no longer serviceable, and one 3-drum stirling type 400 psi boiler. The switchgear was made up of small oil circuit breakers and an open bus, and was inadequate in every respect. The 150 psi equipment was over 20 years old, and operated at very low efficiency. The 400 psi equipment was installed in 1941, but operated with only fair efficiency. The fuel used was natural gas with a heat value of approximately 1000 Btu per cu ft with oil for standby.

The plant was originally equipped with reciprocating steam engines, and the turbines were added one at a time as the loads increased. The result was a layout which was none too good, and a plant filled with crannies and nooks which was very difficult to maintain. The general condition of the building was poor.

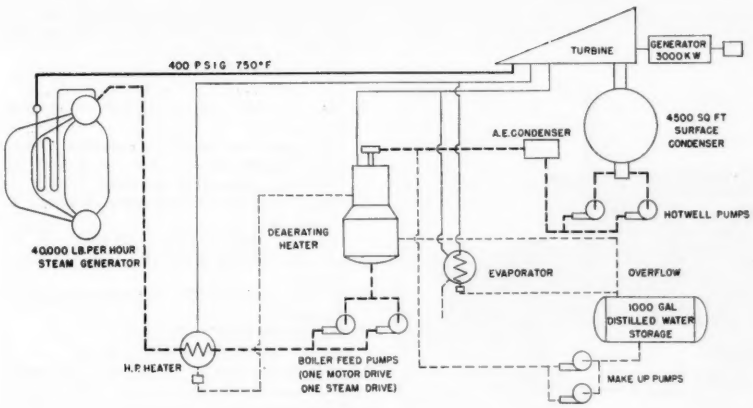


Fig. 3. Piping Diagram

The plant was not connected to any outside source of power, and therefore it was necessary that sufficient equipment be installed to carry the load with one machine out of service. The existing equipment could carry up to 2500 kw with one machine down provided the boilers could produce sufficient steam. However, the experience had been that the 150 psi boilers could not be expected to carry that much load if it became necessary to use them alone. In any event it would at times be necessary to run one of the low pressure turbines, and thus cut the plant economy seriously. Due to the age and general condition of the low pressure equipment it was considered unwise to depend on it for anything but standby service.

The problem was to provide new equipment which would carry the anticipated loads dependably and economically, and to maintain in service sufficient older equipment to carry the load when the new equipment was out of service. The following plan was decided upon as the best solution to the problem.

New Plant Built on Settling Basin

A new 3000 kw, 400 psi, 750 F, turbo-generator with a steam generating unit and feedwater heaters to serve it was decided upon as the major equipment. It will be housed in an entirely new building. All of the existing equipment will be kept in service in the old building in order to provide sufficient capacity to carry the load when the new unit is out of service.

The possibility of extending the old building to include the new equipment was explored but found to be impractical. It happens, however that a major remodeling of the municipal water plant located close by retired from service a large water settling basin which was just the right depth to form the excavation for the new power plant basement. The size of this basin is sufficient to receive the new plant and provide space for any probable expansion. Therefore, the new plant is being built in one end of the old settling basin. (See Fig. 1). Work on it started early this year.

Due to the existing excavation being used, the most economical building arrangement proved to be one in which the boiler operating floor and the turbine operating floor are at different levels. The turbine room floor elevation is being established sufficiently high to allow the installation of a condenser for a 7500 kw turbine in future construction without the necessity of changing the elevation of either the basement or turbine room floor. A 20-ton hand operated crane serves the turbine room. The space in front of the boiler and directly above it is being left clear for a future coal hopper and the space below the boiler is left clear for future ash handling equipment. The fuel now used is natural gas with oil for emergencies.

Turbine Room Floor of Removable Steel Panels

The turbine room floor is made of removable steel panels so that the crane may be used to pick up any equipment in the basement. A large rolling door is provided at one end of the turbine room. This door permits backing a truck into the building and on to a platform placed at the same level as the boiler room floor. Thus the crane can be used to lift equipment directly from the truck.

A new screen house with a traveling screen is to be built on the river bank. The circulating water will be conveyed from the screen house to a tunnel under the basement of the new plant in a 42 in. reinforced concrete pipe. This pipe is much larger than necessary for conveying the amount of water which is likely to be needed. The size was determined by the method of installation. The pipe is to be jacked under the existing plant. Forty-two inches is about the minimum diameter in which men can work. The earth is dug out at the head end as the pipe is pushed forward.

The superstructure of the building consists of a steel frame covered with insulated metal panels. The panels are 3 in. thick and are composed of a steel sheet on the inside face and an aluminum sheet on the outside, separated by fiberglass insulation. The roof is a flat steel deck covered with 1 in. of insulation and a tar and gravel roofing. Figure 2 shows a longitudinal section of the plant.

A regenerative steam cycle is being used. (See Fig. 3). Steam conditions are 400 psi 750 F. The turbine has two bleed points, and a deaerating heater and closed heater are provided. The deaerating heater is of the storage type, having 1000 gallons capacity, and is used as the surge tank for the system. Make-up water is provided with a single effect evaporator. The evaporator uses treated water from the adjacent municipal water plant for its supply. All trap drains and the deaerating heater overflow are piped to a 1000-gallon distilled water storage tank located in the basement, and make-up water is pumped from this tank to the deaerating heater as required.

The steam generating unit is of the two drum type, rated 40,000 lb per hr continuous, 48,000 lb per hr for 4 hours. It is equipped with water cooled walls, air preheater, forced and induced draft fans, soot blowers, combination gas and oil burners and automatic combustion control. Guaranteed full load efficiencies are 81.4 per cent for gas and 84.9 per cent for oil. A by-pass duct with thermostatically controlled damper is provided around the air preheater to keep the temperature of the flue gas in the heater above the dew point.

The generator is wound for 2400-

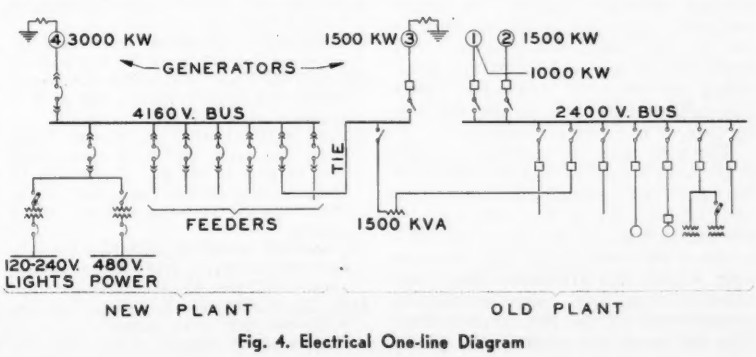


Fig. 4. Electrical One-line Diagram

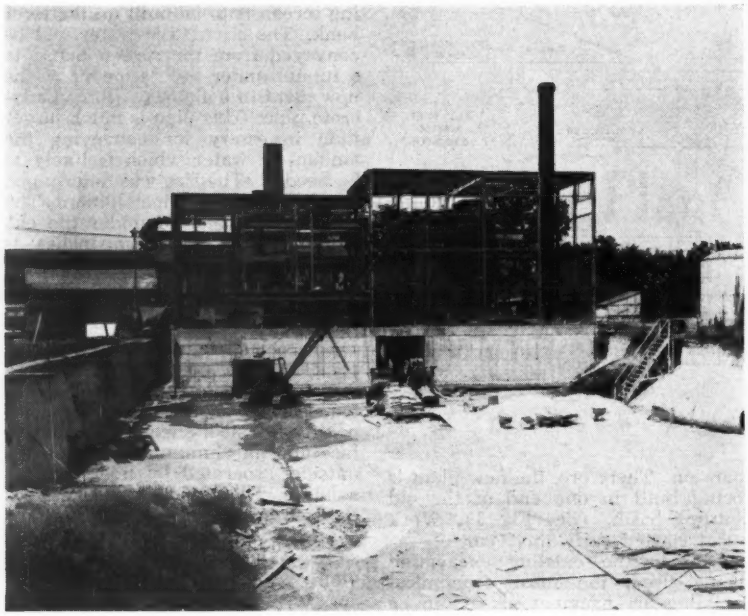


Fig. 6. Construction View

4160-v, wye. All new metal clad switchgear with air circuit breakers is being installed in the new plant. The one-line diagram (Fig. 4) shows the main connections. Two of the machines in the existing plant are wye connected with a phase to phase voltage of 2400, and the third is delta connected. The delta connected machine is to be reconnected for 2400-4160-v, wye, and will be tied directly to the new plant bus. The other machines will be connected to the new plant bus through a 1500 kva auto transformer. All feeders are to be converted from 2400-v delta to 2400/4160 v wye.

Three-phase station power at 480 v is provided by a 300-kva "power center" or unit substation consisting of an air cooled transformer, a main secondary circuit breaker, and six secondary feeder breakers. The 120-240-v single phase energy for lights and small equipment is provided by a 25 kva pyranol filled distribution type transformer mounted in a metal clad cubicle together with a primary fuse and a secondary breaker. This cubicle matches the main metal clad switch gear in appearance. A 120-v station storage battery furnishes power to operate the circuit breakers in the main switch-gear. An automatic throwover switch is provided to connect certain lights throughout the plant to the battery in case of a-c power failure.

The new plant is expected to operate with a heat rate of about 16,000 Btu per kwhr which is twenty per cent below that of the best unit in the existing plant. It will be possible to carry the entire load with the one unit, which will eliminate the extra expense resulting from putting a second unit on the line once a day. The full economy of the new plant will of course not be realized until a second unit is added and the old plant retired from service.

PRINCIPAL EQUIPMENT OF IOLA, KANSAS POWER PLANT

STEAM GENERATING UNIT — Babcock & Wilcox.
2—drum bent tube type. 40,000 lb per hr continuous rating, 48,000 lb per hour 4 hours rating. 4858 sq ft effective heating surface. Furnace volume 2130 cu ft. Heat release at 48,000 lb per hr output; gas firing 30,300 Btu per cu ft, oil fired, 29,300 Btu per cu ft. Superheater surface approximately 1265 sq ft. Air heater, tubular type, 3 pass, with 3650 sq ft. of heating surface. Burners are B & W combination gas and oil type.

SOOT BLOWERS, Diamond Power Specialty Corp. Automatic Valve-in-head type.

INDUCED DRAFT FAN—American Blower Corp.

FORCED DRAFT FAN—B. F. Sturtevant.

COMBUSTION CONTROL—Hays Corporation.

TURBO-GENERATOR—General Electric Co. 3,000 kw 80 per cent pf 2400/4 160 v.

CONDENSER—Worthington Pump & Machinery Corp. 4500 sq ft, divided water box, two pass with element two stage aid ejector and hogging ejector.

CIRCULATING PUMPS — 2 — Worthington Pump & Machinery Corp. 3000 gpm each.

CONDENSATE PUMPS. 2 — Worthington Pump & Machinery Corp.

EVAPORATOR—Condenser Service and Engineering Co. 600 lb per hr, single effect.

CLOSED FEED WATER HEATER—Condenser Service and Engineering Co. 120 sq ft of surface.

BOILER FEED PUMPS—2—Warren Steam Pump Co. type 1½-TM, 6 stage, 3500 rpm, 96 gpm at 527 psi. One driven by 75-hp General Electric motor and one by 75-hp type DS-114 General Electric steam turbine.

FEEDWATER MAKE-UP PUMPS—2—Fairbanks-Morse, Figure 5553 "Built-Together" pump. 3450 rpm, 40 gpm at 44 psi.

FUEL OIL PUMP—Sier-Bath Gear Co., size A internal gear screw pump. 10 gpm at 100 psig.

AIR COMPRESSOR—Ingersoll-Rand Co. 6 by 6 by 5 by 5 in.—Type 40—Model 25 B. Rated 115 cfm at 100 psig.

AUTO TRANSFORMER — General Electric Co. 1,500 kva OISC, 4160Y —2400Y.

METAL CLAD SWITCHGEAR — General Electric Co.
One generator panel, one exciter panel, and 7 feeder panels. Bus rated 4160 v, 1200 amp. Air circuit breakers.

TRAVELING CRANE—Manning, Maxwell & Moore, Inc.
Shaw-Box, hand operated, 20 tons.

STATION POWER CENTER—General Electric Co.

STATION LIGHTING CENTER — General Electric Co.

STORAGE BATTERY—Philco.
60 cell, glass jar, lead-acid type.

TRAVELING WATER SCREEN—Link Belt Co. Model 45. 3 ft 8½ in wide trays. 9 ft submersion at normal water elevation.

Individuals and firms involved in the construction of the Iola plant are as follows:

City Engineer, Morris B. Willis.

Engineers in charge of design and supervision of construction, BRINK-DUNWOODY-COOPER, Architect-Engineers, Iola, Kansas.

Mechanical Engineering consultant, O. K. Johnson, Topeka, Kansas.

General Contractor, Douglas Construction Co., Topeka, Kansas.

Electrical Contractor, Hill Electric Co., Wichita, Kansas.

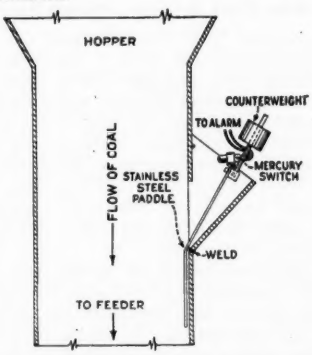
Poping Contractor, Bruce Calder, Topeka, Kansas.

Boiler Erection, Smiley Equipment & Construction Co., Kansas City, Mo.

PULVERIZED COAL EXPLOSION

AN EXPLOSION in the firebox of a large pulverized-coal-fired boiler at a midwestern glass factory resulted from an interruption in the coal feed, which extinguished the flame and let unburned coal into the firebox. The operator shut down the boiler immediately after the explosion and shifted its load to a standby. Boiler tubes were displaced and distorted and about twenty-five feet of breeching was ripped open.

An alarm to warn the operator of any interruption in the flow of coal to the pulverizer is needed for safe operation.



A suggested type of coal alarm that can be made up by plant mechanics. The stainless steel paddle is installed in the feed pipe to the pulverizer, and in normal operation is held against the side of the pipe by the stream of passing coal. If the stream is interrupted, the counterweight lifts the paddle and trips the mercury switch to operate an alarm

How the Heat Pump Works...

THE HEAT PUMP, like a refrigeration machine, pumps heat from a low temperature source to a high temperature reception. In a household refrigerator, heat is withdrawn from the low temperature refrigeration compartment and pumped into the comparatively high temperature air outside. When a refrigeration machine is employed for heating and cooling a home, it is called a heat pump. During the heating season, the equipment is arranged so that heat is withdrawn from some outside medium—such as the ground, air, or well water—and pumped into the home. During the cooling season, heat is withdrawn from the home and pumped into the outside medium.

Figure 1 illustrates a simple heat pump system with valves arranged for heating as explained in a recent exhibit by the Department of Mechanical Engineering, Illinois Institute of Technology. In this case the outside medium from which heat is withdrawn is the ground. A fluid called the refrigerant (usually Freon-12) circulates through the system and alternately absorbs and rejects heat. The refrigerant fluid emerges from the expansion valve as a low pressure liquid at a sufficiently low temperature to absorb approximately two units of heat energy from the ground. As a result of this absorption of heat, the cold liquid is vaporized into a cold gas. In the compressor the cold low pressure gas is compressed to a much higher pressure and temperature at the expense of work equivalent to approximately one unit of heat. This is supplied to the compressor by an electric motor.

After compression, the one unit heat equivalent of the work, together with the two units of heat energy absorbed from the ground, is transferred to the air passing over the air coil on its way to the distribution system of the home. The loss of heat suffered by the warm refrigerant gas in passing through the air coil condenses it into a warm liquid. This warm liquid flows under high pressure, first into a receiver tank, and then to the expansion valve, where its pressure is greatly reduced. The result is a sharp drop in temperature of the refrigerant liquid. It is now cold enough to absorb another quota of heat from the ground. The refrigerant is simply the heat absorbing and transmitting fluid, while the compressor is its motivating agent.

During a cycle three units of heat, two from the ground, and one from the electrical energy supplying the motor, are added to the home. Only one unit of this heat, that of the electrical energy supplied, must be paid for. Thus the heat pump delivers approximately three units of heat for each equivalent unit of electrical energy purchased—a great saving in energy which should ultimately result in wide use of the heat pump on farms and in the suburbs where electricity and a large amount of ground or well water is available.

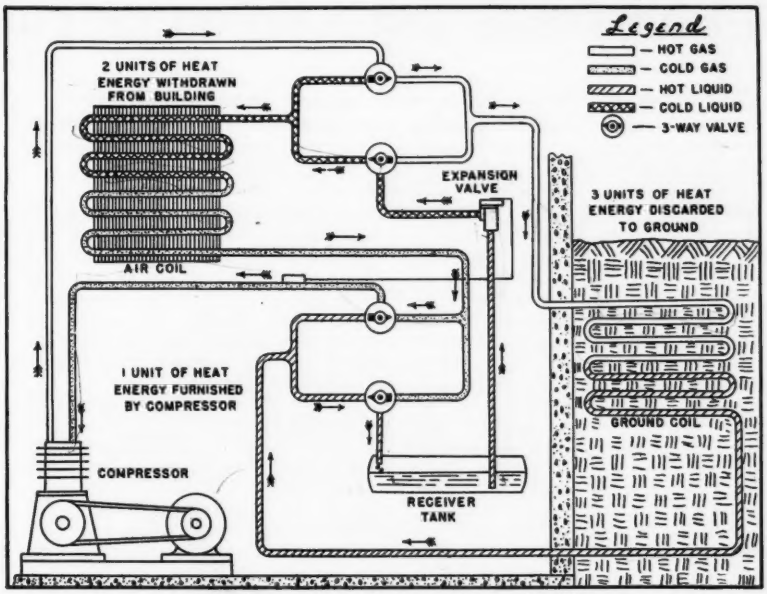


Fig. 2. Heat pump cycle arranged to cool building

During the summer months the same unit can be employed for cooling the home by switching the valves so that the refrigerant absorbs heat from the air going into the home and discards it to the ground outside. The system when operating in this manner is shown in Fig. 2.

The heat pump is an ideal heating system. Although it is still in the early stages of development, it offers excellent promise for the future. It can be made to switch automatically from heating to cooling and to respond to a thermostat located in the home. It could thus be made to serve as a fully automatic year-round air conditioning system. There would be no need for coal or fuel oil storage or chimneys; and very little supervision would be required. In case of emergency due to failure of electrical current, a small gasoline engine could be used to drive it.

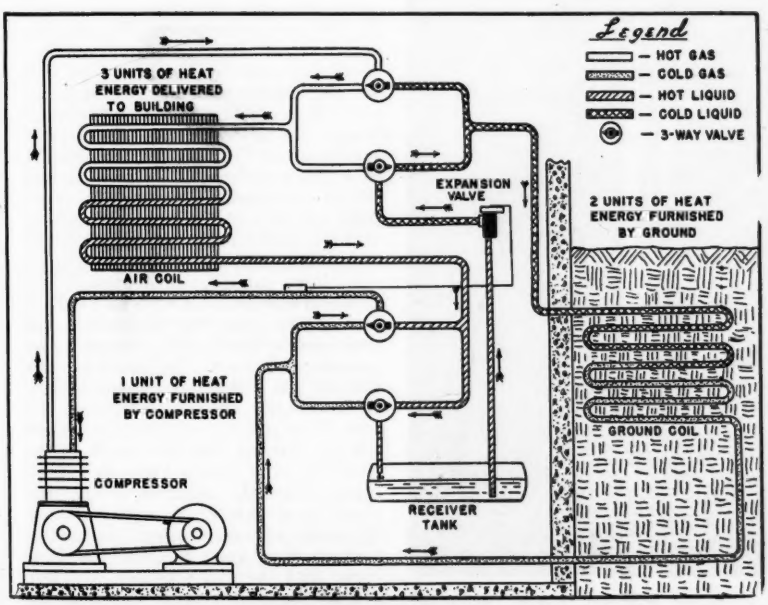


Fig. 1. Heat pump cycle arranged to heat building

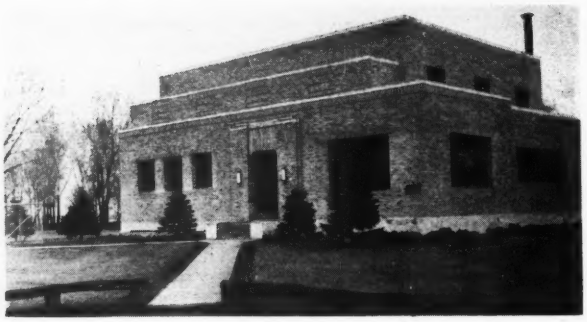


Fig. 1. This attractive brick building houses the three Fulton diesels which supply Plattsburgh, N. Y., with electricity

14.68 Kwhr per Gallon of Fuel Oil

Three 1000-hp Fulton Diesels at Plattsburgh, N. Y., reach high efficiency level as standby plant produces 16 million kilowatt-hours in eight years

THE EXPERIENCE of the Plattsburgh, N. Y., Municipal Lighting Department demonstrates the value of designing standby power plants for efficient, heavy-duty operation. Planned as insurance against the possible inadequacy or failure of hydro-electric power, the three 1000-hp Fulton diesels were put into service on April 10, 1941, and ran more than 8000 engine hours in the balance of the year, generating 5,977,100 kwh. In less than eight years, this standby plant has produced more than 16,000,000 kwh.

With production of this volume, operating economy has been a matter of prime importance and the foresight of Plattsburgh engineers in building for maximum efficiency has paid handsome dividends. When the engines are operating at full load, output has been as high as 14.68 kwh per gal of fuel consumed, an unusual figure for normally-aspirated diesels. In five of the eight years, average production has been above 14 kwh per gal.

By the end of 1948, the plant had generated 16,019,400 kwh while consuming 1,163,737 gal of fuel, an average of 13.76 kwh per gal. But Plant Superintendent W. W. Gottburg explains that the average was pulled down by the years 1942 and 1943 when the engines ran a lot with very low kilowatt load but high kva load to correct voltage in the system.

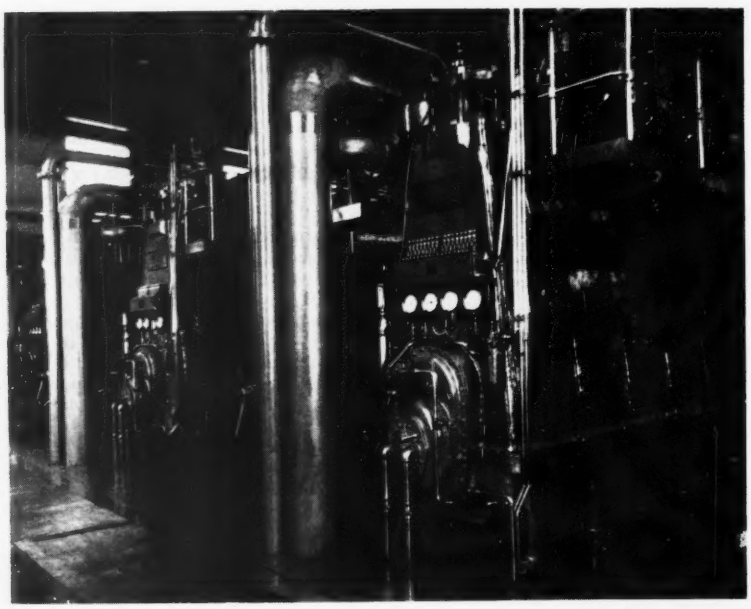


Fig. 2. All three Fulton diesels at Plattsburgh, N. Y., are 8-cylinder, 4-cycle, mechanical-injection units of 17½ in. bore and 24½ in. stroke, rated at 1000 hp at 225 rpm

Lubricating oil economy has been equally impressive. In 1948, the diesels ran 4361 engine hours and consumed a total of just 424 gal of lube. This means an average of 10,285 hp hr per gallon.

Plattsburgh, city of 22,000 population on the shore of Lake Champlain, voted in 1937 to set up a municipal power system. The New York State Electric & Gas Co. was in receivership and service conditions were far from satisfactory. The city negotiated purchase of the distribution system within its limits and contracted with the Eastern New York Power Co. for a supply of power from four hydro stations on the Saranac River. It was conceded that the city could not produce electricity in fuel-burning plants for less than 7 mills per kwh. It paid for hydro power, but officials felt it their duty to provide a dependable standby in the event that familiar hydro shortages reoccurred.

To provide this insurance, Plattsburgh installed three four-cycle, mechanical-injection Fulton diesels, of eight cylinders, 17½ in. bore and 24½ in. stroke, delivering the rated 1000 hp. at just 225 rpm. When installed, this 3000 hp plant could carry the entire city load and gave complete standby protection. The demand has gone as high as 5400 kw in the past year but the diesels still can handle the full residential and commercial load. In practice, the diesels are called on to supplement hydro supply when water stocks are low. Thus plant production low during the Spring, rises to a peak in the Summer and early Fall, drops off again after the autumn rains, and rises moderately in late Winter. Volume of generation fluctuates widely from year to year but it is clear that the city's power situation would be precarious without the diesel plant.

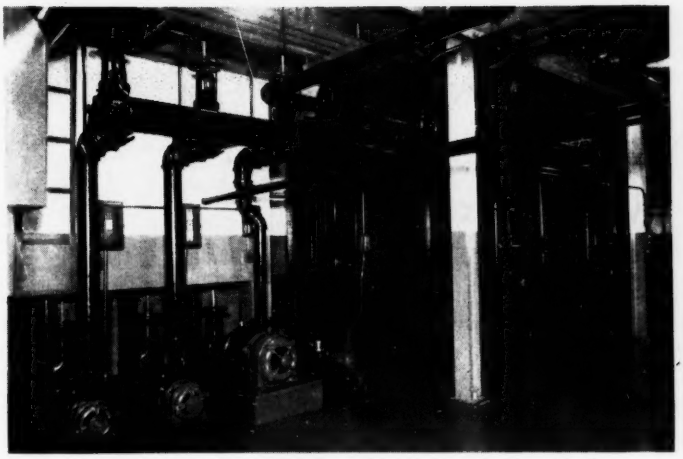


Fig. 3. A common header for the three evaporative coolers, another for the three engines, and a third for the three pumps that send cooling water from a hot well through the engines and coolers assure maximum flexibility in Plattsburgh's system

Fig. 4. Lubricating oil is transferred from the engine sump tank and put through this lube purifier after every 300 to 400 operating engine hours

Only soft water enters the engine jackets and a closed cooling system prevents contamination. The water is circulated by three motor-driven centrifugal pumps from a hot well, through the diesels and through the coils of three evaporative coolers. Coolers and pumps are arranged so that any combination of units may be used. Thermostatic controls bypass water around the coolers and position cooler shutters to keep the cooling water at the prescribed temperature. For makeup, city water is treated in a zeolite softener.

All intake air is cleaned in three oil-bath filters placed just outside the building. There is adequate storage (three tanks totaling 44,000 gal) for the No. 2 fuel oil. All fuel is metered and filtered before reaching the engine injection systems. There is always an operator in attendance and he has the assistance of an alarm system and a specially well-equipped 14-panel switchboard.

Business Manager S. W. Niles reports that the department has been able to keep rates low and still show a good margin of profit. In 1948, the average per kwh paid by residential consumers was 2.92 cents, commercial 2.56 cents, and industrial 1.30. The department's 1948 report shows contribution to the city of $127,325.30 in eight years, retirement of $133,000.00 of plant bonds, and $137,504.76 in cash on hand.

Mr. Gottburg reports that there has not been a single interruption of power supply in the past eight years.

To both these records, the efficient diesel plant has made important contribution.

IN THE NEW Philips hot air engine, a novel regenerator of amazing effectiveness is used. It consists of a coil of fine steel wire crimped to expose more surface. It heats the air flowing through it from 250 F to 1,000 F and cools it again to 250 F all at the rate of 3000 times a minute.

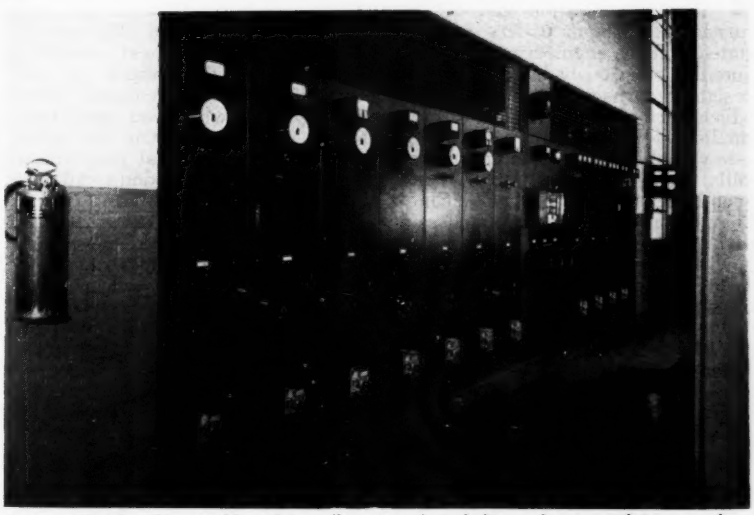


Fig. 5. Plattsburgh's switchboard is well equipped, including voltage regulators, synchroscope, recording kwa demand meter, totalizing kwhr meters, ammeters, kw meters, pf meters, ground detector, and multi-point exhaust pyrometer

Principal Equipment Listing

Engines	Three 1,000 hp, 8-cylinder, 4-cycle, mechanical-injection Fulton diesels operating at 225 rpm. Fulton Iron Works Co.
Generators	General Electric Co.
Air Filters	American Air Filter Co., Inc.
Snubbers	Burgess Manning Co.
Evaporative coolers	Buffalo Forge Co.
Centrifugal cooling water pumps	One Buffalo driven by Louis Allis motor. Two Ingersoll-Rand Co. pumps driven by General Electric Co. motors
Water softener	Graver Tank and Mfg. Co.
Compressors	Two, Quincy Compressor Co.
Fuel pumps	Two, Viking Pump Co. driven by Westinghouse Electric and Mfg. Co. motors
Lube oil	Shell Talpa in crankcase. Shell Rudus in cylinders
Lube oil cooler	Ross Heater & Mfg. Co., Inc.
Lube oil purifier	Youngstown Miller
Cylinder lubricator	Manzel Brothers Co.
Governors	Woodward Governor Co.
Switchboard	Westinghouse Electric & Mfg. Co.
Engine gages	Jas. P. Marsh
Voltage regulators	Westinghouse Electric & Mfg. Co.
Thermometers	Moeller
Pyrometer	Brown Instrument Co.
Alarms	Edwards
Switchboard instruments	Westinghouse Electric & Mfg. Co.
Crane	Conco Engineering Works
Hoist	Budget

FUEL FIRING

What Does It Cost You to Burn Waste Fuels?

Maybe it costs you more than they're worth . . . How do you know? . . . Do you have any figures to prove it one way or another? . . . Do you have proper boilers and furnaces, measurements of feedwater, fuel, furnace draft? . . . Perhaps it would pay you to burn gas, oil or coal instead . . . Questions that you must answer if you want to get the most out of your waste fuels

By J. R. DARNELL,
Consulting Engineer

THE CHIEF ENGINEER of a large organization that designs furnaces for steam boilers recently stated that his engineering staff frequently is seriously handicapped in designing furnaces for boiler plants which burn waste fuels. Most of the smaller plants which burn such fuels —saw mills, planing mills, paper mills, sugar refineries, etc.—do not keep boiler room records. The Chief Engineer previously mentioned said that many such plants do not know how much steam they produce, nor do they even have a feedwater meter by which they could determine how much water is pumped to their boilers. He said that his company has a water meter which is often loaned to prospective customers so that the proper size of furnace can be designed for whatever load is needed. However, some plants won't install the meter or let the engineering concern do it.

To operators of most boiler plants, where the fuel has a tangible cost, the above is really astounding. We say TANGIBLE cost because, although you do not know it, Mr. Plant Manager, the so-called waste fuel which you burn under your boilers does cost you real money, and quite frequently, the cost is exorbitant. In some cases, Mr. Manager, your costs would be far less if you actually did buy your fuel. You would know how much your fuel cost is and you probably would be curious enough to want to know what you are getting for your money. You would want to know how many pounds of steam your boilers are producing for each pound of fuel burned.

Whether you burn sawdust, bark, shavings and blocks, bagasse, old rubber tires or garbage, there are several hidden cost items which must be totaled in order to arrive at your steam cost. Do you think that because you burn sawdust or bark, you are getting steam gratis? Nothing could be further from the truth!

Probably you burn your sawdust or bark under a multiplicity of low set hrt boilers which produce as much smoke as a naval destroyer laying a smoke screen. The soot insulates the boiler heat absorbing surfaces and the output of each boiler is greatly reduced. Then comes a day when you need more steam. You are going to install another engine, so that you can cut more logs. But you don't call in a competent engineering firm to advise you. With what you think is cheap common labor, you think you can erect another hrt boiler without any outside help. You buy and erect the boiler and start making more smoke but get only half as much steam as you should. This piece-meal erection of hrt boilers is nothing new—you've done it several times before. That is why you now have 8 or 10 hrt boilers instead of two or three boilers with properly designed furnaces.

We have no quarrel with the manufacturers of hrt boilers. In some cases and within certain limitations they will do as good a job as water tube boilers, if they have the proper furnace design. In all probability, you could now be getting your required steam production with four or five hrt boilers and at a lot less cost if you had kept operating records and had called in competent engineers to design proper furnaces for those hrt boilers as you added new boilers to your collection each time you needed more steam. Furthermore, you might be able to handle present steam demand plus 50 per cent greater load in the future with two or three water tube boilers having properly designed furnaces and at much less operating cost. With proper furnace design and the necessary instruments one competent fireman might replace three of the variety you now employ.

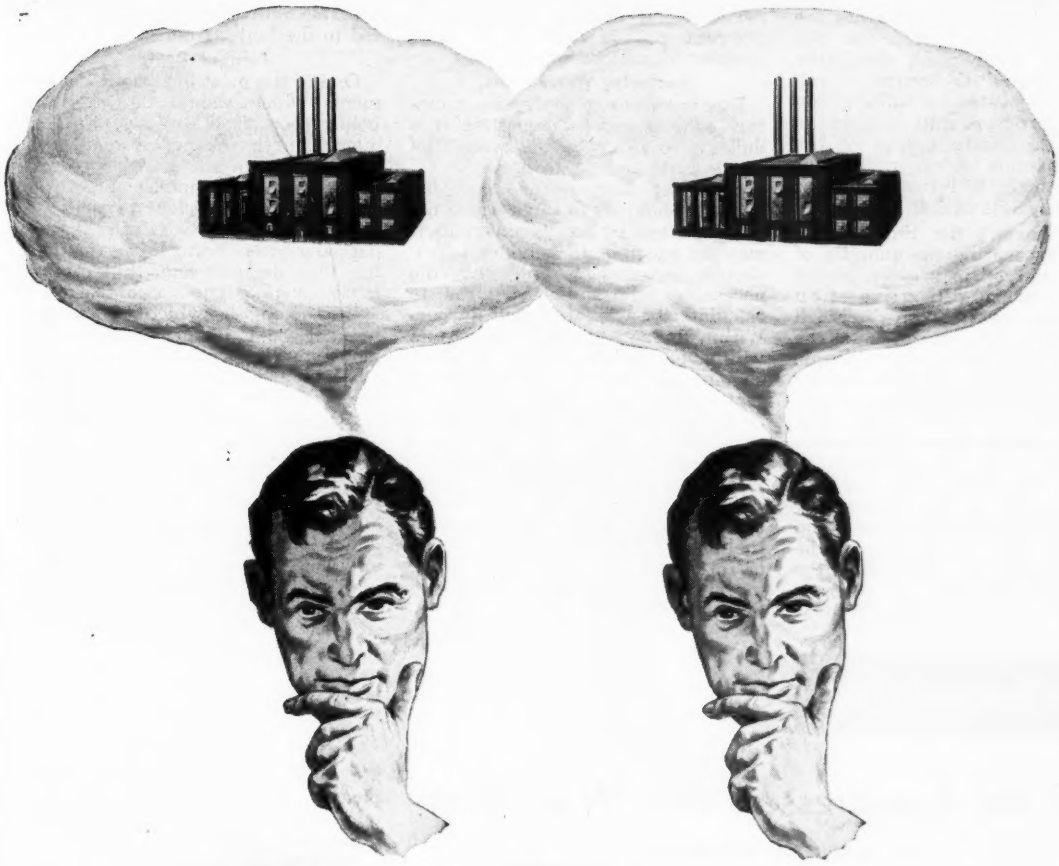
Delving even further into the question of whether so-called "waste" fuels cost more to burn than conventional fuels such as oil, gas or coal, at each site where waste fuels are available, an economic study should be made to determine whether the cost of handling the greater bulk of these waste fuels plus the potentially lower combustion efficiency of such fuels, might result in a decision to burn gas or oil. Is that rank hersey? Some of the old timers will say, we are crazy to suggest burning gas or oil in a saw mill but in some cases it can be shown that the necessary steam can be produced at less cost by burning gas or oil and converting the saw-dust into valuable by-products such as tar, tar oils, creosote, turpentine, acetic acid, methyl alcohol, acetone and charcoal. Wood flour and cellulose acetate (plastic wood) also can be produced. In some plants they are now making pressed wood with saw dust and a plastic binder. How many thousand tons of valuable chemicals are wasted annually by burning so called "waste" fuels probably never will be known.

Natural gas has a heating value of about 22,000 Btu per pound; fuel oil, 18,000 to 19,000 Btu; while most wood waste fuels with moisture contents from 45 to 65 per cent have heating values of 4000 to 5000 Btu per pound. Furthermore, due to the greater bulk of material and the necessity for higher percentages of excess air, in order to obtain complete combustion, a good furnace design for wood waste may result in 60 to 75 per cent boiler efficiency whereas oil or gas will produce 75 to 90 per cent.

Measuring Feedwater

If the top "brass" in your organization is so short sighted that they won't even let you buy a feedwater meter, you can use your pump as a meter, if you can manage to purchase a small instrument known as a "counter." It registers either strokes or revolutions and by measuring the water and counting the strokes or revolutions in a definite period of time, you will have the necessary information to calculate how much water you pump to your boilers.

Then, if you can estimate or meas-



Think Twice...

. . before you select *any* water conditioning service.

In the selection of the water conditioning service *best* suited for *your* boiler plant, it will pay you to consider carefully these three vital factors for successful, economical boiler plant operation:

- A service based on a sound engineering background
- A service with a proved record
- A service backed by ample engineering facilities

Trouble-free operation is a result of scientific control.

W. H. & L. D. BETZ is an organization of engineers and chemists specializing in the solution of all industrial water problems. Years of experience have made Betz water conditioning service scientifically correct . . . complete . . . economical.

Our nationwide staff of engineers will welcome the opportunity of discussing with you this important subject of water conditioning . . . W. H. & L. D. BETZ, Gillingham and Worth Streets, Philadelphia 24, Pa. In Canada: Betz Laboratories Limited, Montreal 1.

BETZ

BOILER WATER CONDITIONING • COOLING WATER CONDITIONING • INDUSTRIAL WASTE TREATMENT

ure the water discharged from the boilers as "blow-down," the net amount of water must equal the steam produced. Of course, if you measure the water in gallons, you must convert to pounds in order to compute the steam output of the boiler in pounds. A gallon of water at 62 F weight 8.34 lb and weighs only slightly less at 100 F.

If you haven't the time or the means of measuring the quantity of water discharged in a given period of time, you can still arrive at an approximate amount of water fed to your boilers, if you can count the strokes or revolutions of your pump. A reciprocating pump theoretically displaces the cubical contents of each of its pistons at each stroke, but in actual practice there is a certain percentage of "slip" for which allowance must be made. This slip will depend in part on the pressure or head in feet against which the pump is working, and of course, on the piston packing, the condition of the valves and the type of plunger. Pump slip may vary from 3 to 15 per cent. If in doubt, assume 10 per cent and you won't be too much in error for estimating purposes.

Measuring Waste Fuels

Due to variations in density, moisture content and particle sizes, it is difficult to estimate the weight of waste fuels fed to boilers. But if your boiler furnaces are provided with feed hoppers through which the fuel is moved by screw conveyors it may be possible to conduct a few simple tests which will give the necessary information required to calculate the weight of fuel burned. Within limits, a given batch of fuel will have a certain density, moisture content and average particle size so that a given bulk will have a more or less definite weight. This means that with the same little instrument previously mentioned, the "counter," you can count the revolutions of the screw conveyor in a given period of time and then weigh the amount of fuel pushed out. The average of two or three test periods, if there is not too much variation from one period to another, should give you an acceptable figure for the weight of fuel fed to the boiler from hour to hour.

Furnace Draft

One of the most important instruments which should be in every boiler room is a draft gage. This instrument is inexpensive and will tell the fireman at a glance the draft in the furnace or uptake or both. If the stack has sufficient capacity to provide an excess of draft in the furnace the boiler fireman can regulate his flue damper and thus obtain fairly good combustion control.

Instruments by which records can be kept are as important in a boiler plant burning "waste" fuels as in any plant burning conventional fuels. They should be as important to the plant owner as a cash register to a retail store merchant.

Management must not forget that there are laws of compensation, that there is always a price to be paid and that we can't get something of value for nothing. Keeping records will show where the colored gentleman may be found in the lumber pile.

AIR COMPRESSORS

Why the Compressed Air Was Wet

By ALBERT H. MOULTON

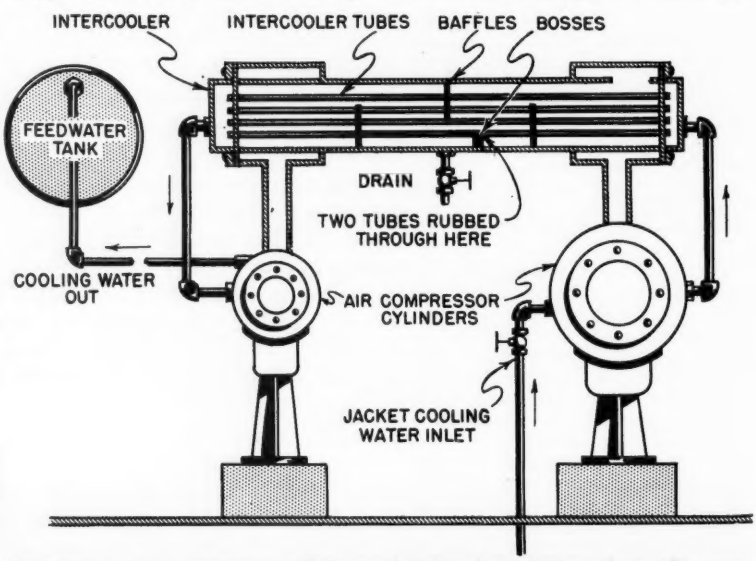
THE MAIN AIR compressor in a granite-cutting plant began to deliver wet air and this condition grew gradually worse until it became quite bad; but part of the trouble was laid to the damp weather we were having at the time. This was a 1500-cfm compressor, two-stage with intercooler, but no forecooler nor aftercooler. City water was used for cooling and was admitted at city pressure, first to low-pressure cylinder jacket, to intercooler and then to high-pressure cylinder jacket, all in series, as shown and discharged to a boiler feed tank to be used for boiler feed. This tank was fitted with a float make-up to provide the remainder of boiler feedwater.

Compressed air was discharged into a large air tank fitted with safety valve and bottom drain, but no trap for automatic drainage, so it had to be drained by hand; it was the duty of one of the maintenance men to open this valve occasionally to drain out whatever water and oil sludge might accumulate. In the past, once a week had been enough and everything went fine.

Then one day the shed foreman came tearing into the engine room, all out of breath and demanding to know, "Whatnell was the matter with the air?" It seemed that their air tools were running on a mixture of air, water and stale oil. Water and oil was spitting out all over the place, damaging stones that were being cut by staining them with oil.

The Chief made a "bee line" for the air tank out in the cutting shed and opened the drain valve. This 1¼ in. pipe blew solid water and oil sludge for about 10 min. before any air came out. It must have been nearly full. No wonder water went over into the air lines; it had no other place to go.

Next day a trap was put in with discharge open to view, and it was plain from the amount of water discharged that there was a leak somewhere in the cooling system. Now we had a problem. The most probable place for it would be in the intercooler for it didn't seem likely that the cylinder jackets could be leaking. The intercooler on this machine at one time had a ½ in. drain



Cross-section of air compressor cylinders and intercoolers, showing where tubes wore through on bosses

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valve in the shell at the lowest point. But a former engineer had taken it off when it began to leak and screwed an iron plug in its place.

This plug was surely put in to stay, for we finally had to drill it out. We then put in a nipple and a ½ in. globe valve and again had a drain on the intercooler. Frequent checks by means of this valve showed there was a leak in the intercooler, for we drew out several pails of water during an 8-hr. run. This machine had been in operation about 10 years, and, as far as we could learn, the intercooler tubes had never been repacked.

We got along until the end of the week, shut down at noon on Saturday and that afternoon opened up the intercooler water boxes and started repacking the tube ends with "corset lacing," and finished Sunday afternoon.

We had no way of testing for leakage except to put heads back on and turn on water, which we did, with drain valve wide open. We waited hopefully but not for long; soon water came trickling out as before.

We had carefully repacked every single one of the tubes so they just couldn't be leaking, at least not to that extent. So it must be either a cracked tube or else a hole worn in one or more, but which one? We had over a hundred to look at. Where could a tube rub to wear a hole in it?

Perhaps vibration had caused tubes to wear against baffles, another tough job for us, so the next Saturday afternoon we started to remove tubes to find that leak. But just as we had taken off the water-box heads, the Chief slapped his thigh and cried, "Wait a minute! I saw a print of that intercooler around some place and I put it away, thinking it might come in handy." He found it, and it showed the air baffles and also two bosses on the bottom of the intercooler shell, about midway. Judging from their size, and location, the lowest tubes must come close to tops of the bosses. Accordingly we took out the two lowest tubes first, and sure enough! both had small holes in them from rubbing on the bosses.

We had no spare tubes, so the master mechanic brazed them for us. After repacking and replacing the tubes we put water box heads back on and turned on the water. With drain valve open we watched with bated breath. For about 20 min. we never took our eyes off that drain. No water came out! We had won.

We didn't try to eliminate the bosses, for they apparently were put in as stiffeners. They were hard to get at; we needed the compressor and didn't want to shut down; we would have had to pull the whole tube bundle; it had taken about 8 yr for the tubes to wear through. So the Chief figured the cost of cutting them out would be more than that of replacing tubes every 8 yr. How did we know the unit would be running in another 8 yr?

I was there for 3 years afterward and there was no trouble in that time.

STEAM TURBINES

Balancing Rotors Without Special Equipment

By FRED E. SCHUBERT,
Chief Engineer
Municipal Light Plant, Columbus, Ohio

LARGE ROTORS may be finally balanced by an ingenious simple method without elaborate or special equipment. An eight-ton field rotor of a 4000-kw turbine generator was balanced by this method using three-quarter inch cut washers, weighing an average of one ounce each. The amplitude of vibration of this unit was reduced, so that a dial indicator placed on the shaft, read only 0.001 in., at the journals, with the unit operating at full speed of 3600 rpm, and under-load. With the dial indicator placed against the bearing housing it read zero movement.

Trying the old custom of standing a lead pencil on its unsharpened end on bearing caps showed it to remain in the vertical position for hours. Temperatures of the oil leaving the bearings were reduced 16F, which is good news in almost all power plants.

Another reward obtained by greatly improved balance was noise reduction. Noise affects the hearing and nervous system of plant personnel. Reduction of noise is bound to result in intangible benefits which are none the less worthwhile. Better personnel relations, less time off, and fewer accidents are some examples.

The design of this machine was such that the air for cooling the generator was taken from outside the building. The heated air was discharged inside the engine room. It was an open machine, so to speak. The noise of this unit in operation was terrific and had intermittent properties. We decided that this change of sound and the noise itself was due to the floating of the field rotor up and down in the bearings, rather than changing of the rotor's position. At a speed of 3600 rpm the noise was quite nerve-racking.

Working on the theory that it could be due to excessive movement of the shaft, the factory's service engineers reduced all journal clearances to ten-thousandths of an inch

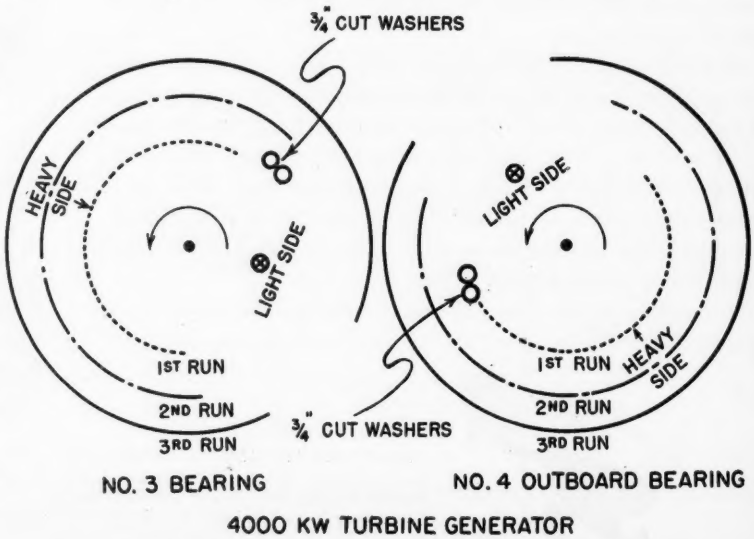
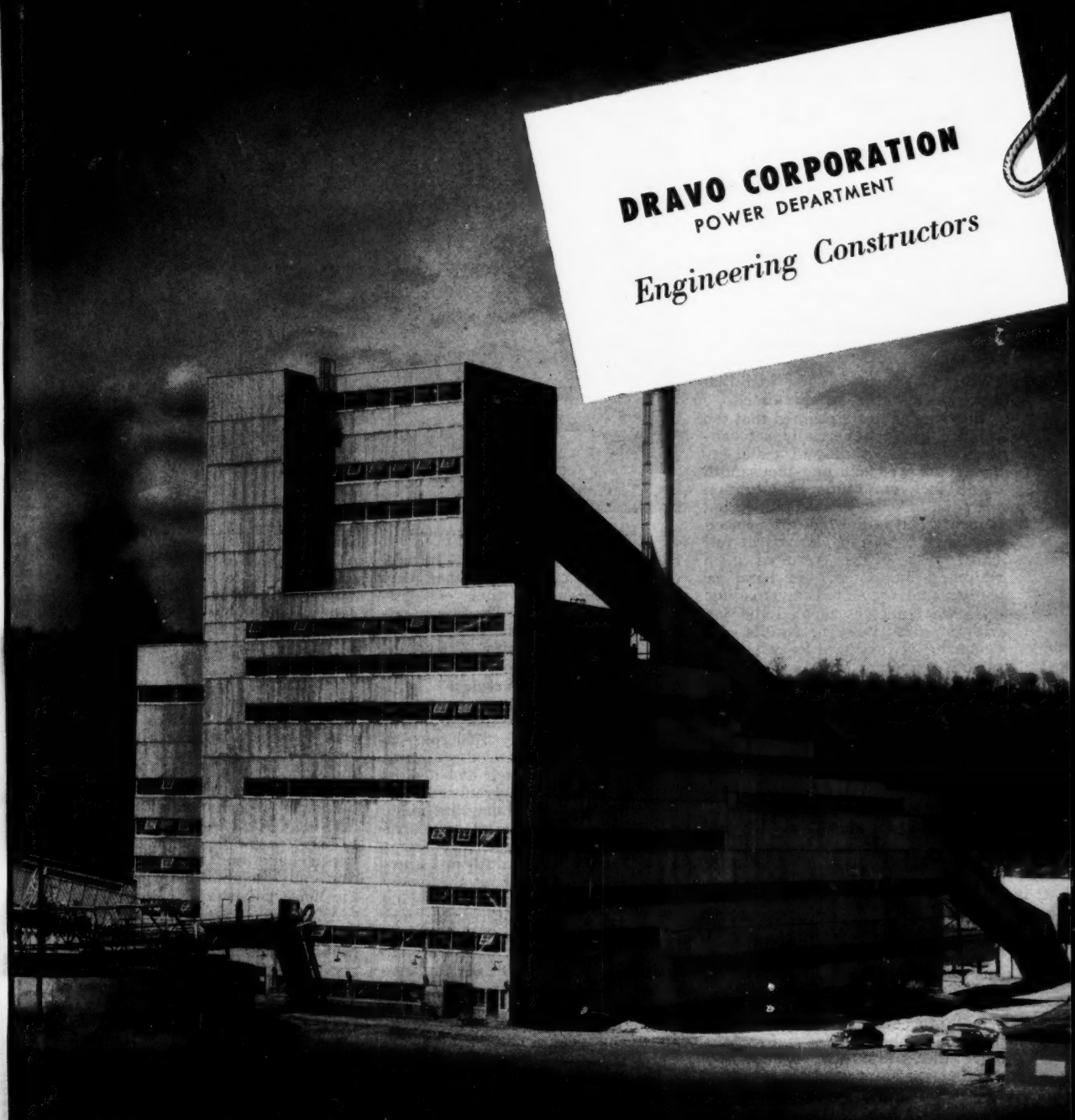


Fig. 1. Diagram showing how scribe marks on shaft led to better rotor balance



H. C. FRICK COKE COMPANY'S new coal preparation plant at Robena Mine, Greene County, Pa. The ultra-modern coal cleaning equipment, complete with wiring, piping and boiler facility, at this U. S. Steel plant, was installed by Dravo Corporation. The experience of Dravo in machinery installation covers a period of more than 50 years.

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total clearance on a six-inch shaft. No apparent or audible improvement was obtained, but instead an undesirable definite increase of bearing temperatures resulted.

Another theory was advanced, that inasmuch as the air for cooling the generator was taken from the outside of the building through a duct, any restrictions in the flow of air could conceivably cause a changing sound. By-passing the outside source of cooling air to an opening inside the building also failed to help. In fact, this change intensified the noise even more. Still we could not dispel the thought that there must be a simple explanation for the noise and that somehow it could be eliminated.

Service engineers claimed that the balance was commercially satisfactory when the reading of a dial indicator showed one one-thousandth of an inch amplitude of vibration with dial indicator placed on bearing housing. But a dial indicator placed on the shaft at the journals at full speed of 3600 rpm resulted in a whipping motion of the hand or pointer that prevented any reading.

So we ourselves tackled the job with most outstanding results. By balancing we produced an extremely smooth running unit which was quiet, with just the uniform hum characteristic of the finely balanced unit. The temperature of oil leaving the bearings dropped to 116 F.

How We Measured Vibration

We are not equipped with elaborate or modern balancing equipment. We resorted to using a steel scratch-awl held against the shaft to indicate its movement during rotation by means of fine marks in a thin layer of whiting made of ordinary powdered chalk and water applied with a one inch flat camel's hair brush to the cleaned shaft.

The person selected to make these important scratches in the whiting must have a very steady hand. The actual procedure is to lightly rest the hand on the machine and slightly move the scratch-awl toward the rotating shaft until there is felt a very faint contact with the shaft. Immediately the scratch-awl is withdrawn because it is desired to obtain a scratch which does not completely encircle the shaft. A scratch partially encircling the shaft is necessary so as to be able to determine from their study the movement of the shaft. This is indicated in direction by the middle of the scratch mark. At the operating speed of the machine a faint contact with the scratch-awl will be sufficient to give a good indication. No doubt the engineer undertaking this method for the first time should practice.

In the case herein described the rotor was manufactured with one-inch tapped holes for installing balance weights. However, a one-inch bolt weighing about one ounce was too short to secure safely. Our special weights, which were three-quarter inch cut washers that were selected because of their convenience in attaching. These we installed under the nuts on the studs that held the ventilating fan on the ends of the field rotor.

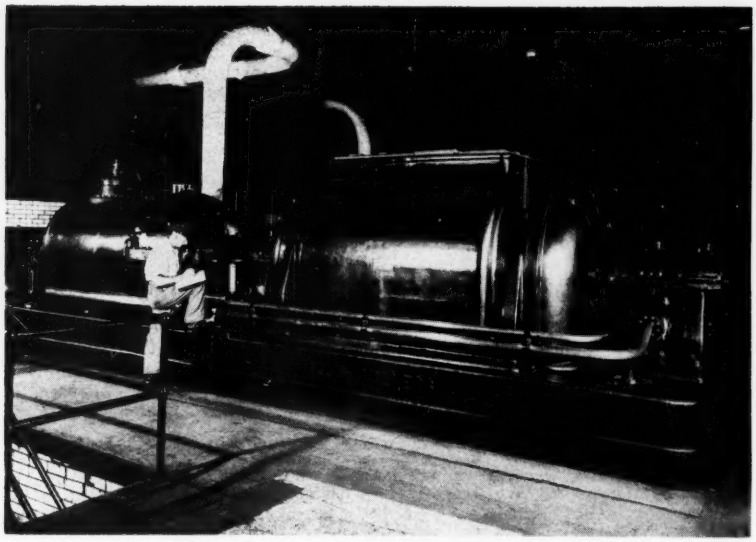


Fig. 2. View of 4000-kw generator in which rotor was balanced as described

Scratch Awl Technique

Our procedure was to operate the unit at no load and slightly over speed (approximately 3700 rpm) to emphasize the unbalanced condition.

Holding steel scratch awl against shaft at top position, produced lines as shown by attached diagram which proved that the cause of unbalance had a twisting effect, that is, a weight placed on the outboard bearing end, would be about the heavy side on the turbine end. And placing weights proved these results; that to receive the effect of any weight placed in rotor at a certain spot, one would have to place the balance weight 45 degrees ahead of light side, in the direction of rotation. By placing ¾ in. cut washer as shown, Fig. 1, produced a definite improvement in operation and definitely lengthening of lines on shaft.

It required 8 trial runs, with some shifting of the washers; it appears that placing of 1 oz washer on one end of rotor sometimes would throw the other end out of balance.

By running lines on both ends of rotor shaft it is possible to check the results of every move or change of weights, for we found the lines were very consistent. The next trial, the blue lines, again proved definite improvement, with lines almost continuous around the shaft, and the noise eliminated.

While I only show three lines, for reasons of simplicity, I did draw a dozen lines and checked results, and it is most interesting to show how two or more lines drawn on shaft under the same condition will consistently produce the same length of lines.

By the use of 1 oz washers the change in lines and operation was very gradual, but still the dial indicator would show improvement and the feel of the bearings also would respond each time there was a change.

I might suggest this point: what makes these results so outstanding from our point of view, is that several Service Engineers have suggested different changes to improve this unit. One suggested change: the thrust bearing from the outboard bearing to bearing next to turbine. This suggestion was carried out, due to fact that the flexible coupling between generator and turbine was unusually long and too free, but still the noise persisted.

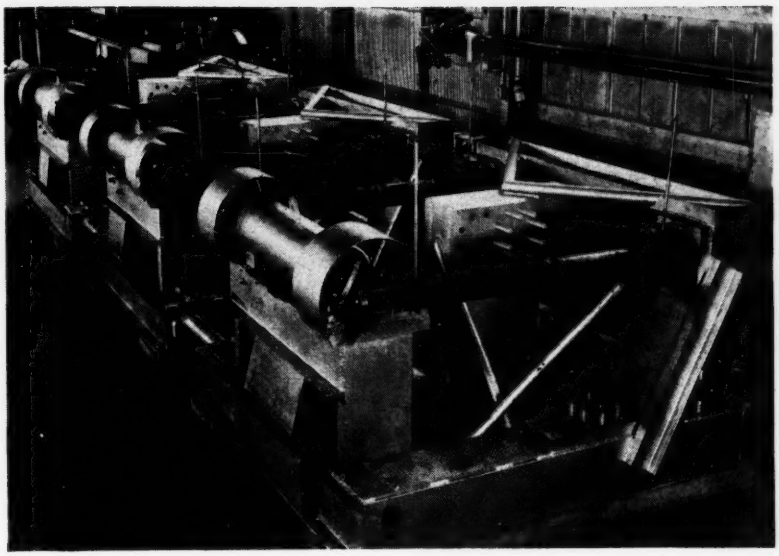
Another suggestion was, since this unit was 28 years old, send spindle back to factory and have it dismantled, stripped, for inspection for faults.

But today, by correcting the balance, the unit operates very satisfactorily, extremely smooth and quiet—a dependable turbine generator.

GRAND COULEE GETS 12th GENERATOR

THE 12th big 108,000-kilowatt generator at the Grand Coulee Dam went into commercial operation September 30 to boost the installed rated capacity of the world's largest power plant to 1,316,000 kw.

Known as R-3, the generator is the third to be completed in the East Powerhouse this year. Six more equally large generators are to be assembled there in the next two years—three in 1950 and the final three in 1951. As the newest generator began pouring energy into the Northwest Power Pool, the Bureau of Reclamation stated that the plant rounded out September with new records.



Strength through Design in Tube-Turn welding flanges

Taking the measure of piping fatigue

PIPE lines are *live, dynamic* members of a piping system. They *breathe* with changes in temperature and pressure. And the danger of fatigue failure from pressure shock, thermal shock, and cyclic conditions is ever-present.

More precise information was needed on this subject. So, Tube Turns research engineers set out to get the answers. For the purpose, they designed and built a unique cyclic testing machine to handle full-size piping assemblies under a wide range of temperature, pressure, and corrosive conditions. And on this torture rack they subjected flanged assemblies to reverse bending tests carried on to ultimate failure. Information revealed forms the basis of new designs for greater strength in Tube-Turn welding flanges.

Other piping assemblies, too—welding elbows, mitre bends, manufactured and fabricated tees, pipe bends—have been subjected to punishment more severe than any they would probably face in normal service.

And this perpetual search for greater strength through better design has paid off in the form of realistic, non-theoretical facts providing a sound basis for Tube Turns' manufacturing policies—facts important to anyone interested in getting his money's worth in long life from piping installations.

Tube Turns' research and development organization, finest in the welding fittings industry, is constantly striving for the improvement of present products, the development of new ones. Notable among their recent achievements have been the design of a new type welding tee and the development of aluminum welding flanges.

Ask to be put on the mailing list for Tube Turns' technical periodical, *Piping Engineering*. Paper 6.01, for instance, deals extensively with standard steel flanges. Others give you research findings and additional working information pertaining to piping not generally available in convenient form.

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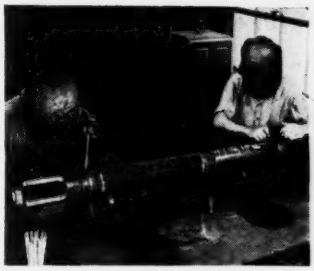
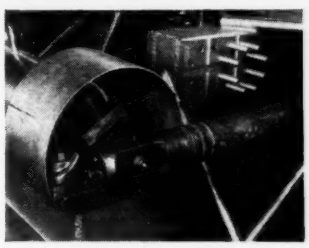
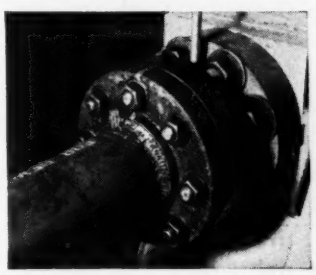
TYPICAL FLANGE ASSEMBLY TESTS



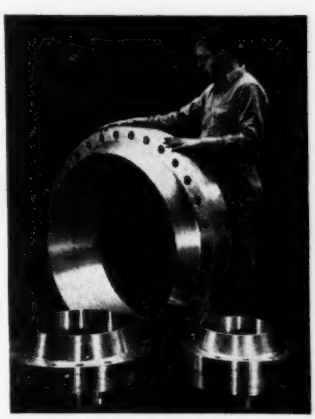
Assemblies were of 4-inch nominal size with 300 pound forged steel flanges and standard weight pipe.



Eccentric crank arm produces up-and-down movement which creates a cyclic bending moment on flange or fitting at opposite end of assembly.



Water spurts from crack in test specimen. Almost invariably, failure occurred in the pipe adjacent to the flange.



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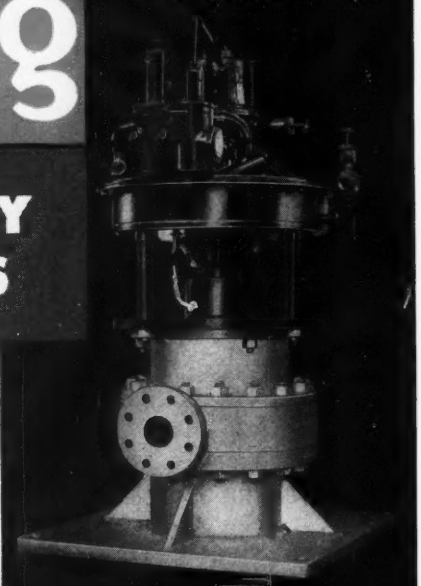

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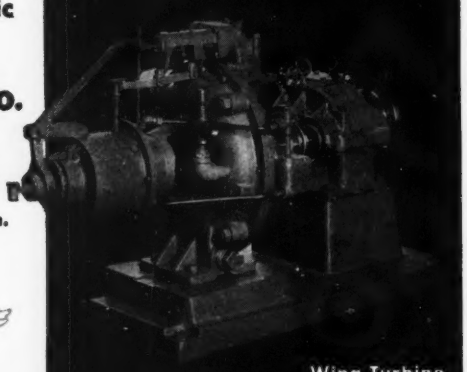

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ENGINEERING IN PEACEFUL WORLD TO BE KEYNOTE OF 70TH ANNUAL ASME MEETING

WITH MORE than 270 speakers drawn from university laboratory and every phase of industry scheduled to deliver some 200 papers, the 70th annual meeting of The American Society of Mechanical Engineers in New York, Nov. 28 to Dec. 2, will be one of the most comprehensive ever offered by the society. Dedicated to the hope that the contributions of technology may be used to further a peaceful world, it is expected that the meeting will attract upwards of 6,000 engineers from all parts of the country. Headquarters will be the Statler Hotel.

James M. Todd, president of the ASME, will deliver the presidential address at the annual dinner on "Honors Night," Wednesday, Nov. 30. He will be preceded on the speaker's rostrum by Dr. H. J. Gough, president of the Institution of Mechanical Engineers of Great Britain. President-elect James D. Cunningham, president of Republic Flow Meters Co., of Chicago, who will take office at the close of the convention, will be introduced. Dr. Lillian M. Gilbreth, outstanding woman engineer, will address the President's Luncheon on the opening day.

A brief outline of the meeting by topic follows:

Applied Mechanics: Six sessions; ten papers on critical loading of columns of varying cross section; bending of an elliptical plate by edge loading; comparison of flow and deformation theories of plasticity, and others.

Boiler-Water Research: Four papers; hideout of sodium phosphate in high-pressure boilers; sulphite and silicate experience at Springdale Station; treatment of make-up in high-pressure by-product steam plants; and automatic degasser for steam sampling.

Fuels: Seven papers on effect of pressure on combustion of pulverized coal; new underground mining procedures; oil-shale processing; practical applications of the anthratube; symposium of fly-ash utilization; report on Illinois smokeless furnace; and gasification of pulverized coal in vortex reactor.

Gas-Turbine Power jointly with other divisions: Survey of AK closed-cycle gas turbines during 1945-1950; 4000-hp gas-turbine locomotive for passenger service; ceramics in gas turbines; metallurgy of gas-turbine materials, and others.

Hydraulics: Three papers on water diversion in the Nantahala Power System; cavitation tests by the vibratory method; water hammer in oil lines; and Hydraulic Oldtimers' dinner.

Industrial Instruments and Regulators: Two sessions; four papers on graphical gear-train design; studies in proportional control; automatic temperature control for electrically heated windshields; and automatic machine for analyzing telemetered-missile data.

Machine Design: Three sessions; eight papers on such subjects as anti-friction bearings, identifications standards, housings and spindles, maintenance, characteristics of greases, oil lubrication, and others.

Marine Power: Two papers, vibration of marine-turbine blading and 28,000-ton tanker design.

Power: Four sessions, ten papers on economics of reheat; costs of reheat versus non-reheat for 100-mw units, steam-turbine blading development, testing of long steam-turbine blading; storing and reclaiming coal with earth-moving equipment; evaluation of steam-power-plant losses by means of entropy-balance diagram; and others.

Safety: Three papers on theory of machine guarding; isotopes as tools of engineering; and handling hot atoms.

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You can burn a wide range of coals efficiently and the exclusive feeder will handle wet or dry coal without clogging. The overthrow impeller—designed after years of trials—spreads the coal evenly. Separate cinder return lines run from *every* cinder drain point—and each return is individually air-jetted into the furnace. Even the overfire air nozzles are individually adjustable.

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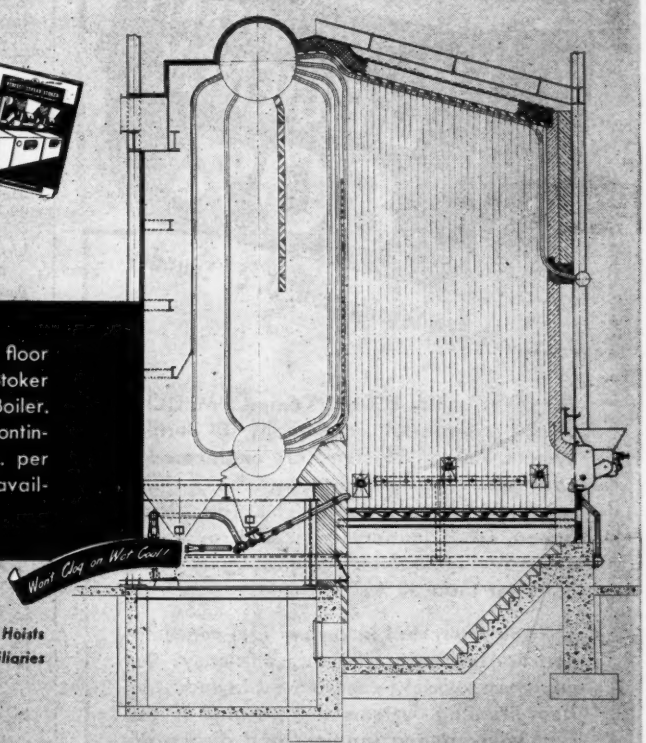

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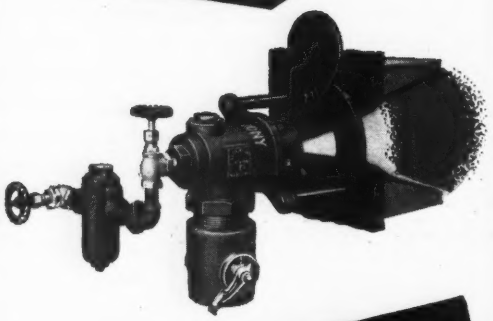

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POWER PLANT Construction News

Forrest City, Ark. — Arkansas Power & Light Co., Pine Bluff, Ark., has work in progress on new steam-electric generating station at Forrest City, previously referred to in these columns, reported to cost approximately $15,000,000, with turbine-generators, high-pressure boilers and auxiliary equipment. Ebasco Services, Inc., 2 Rector St., New York, N. Y., is engineer and will supervise construction.

Cuyama, Calif.—Richfield Oil Corp., 555 South Flower St., Los Angeles, Calif., plans boiler plant, compressor station and pumping plant at proposed new natural gasoline plant in South Cuyama oilfield district, Bakersfield County. Entire project will cost about $4,500,000. Fluor Corp., 2500 Atlantic Blvd., Los Angeles, is engineer.

Los Angeles, Calif.—Lever Brothers Co., 10 Memorial Dr., Cambridge, Mass., plans steam-generating plant at new factory on 30-acre tract of land at Washington Blvd. and Anaheim-Telegraph Rd., East Los Angeles, comprising several large multi-story buildings. A re-cooling water tower and hydrogen plant will be installed. Entire project is estimated to cost close to $25,000,000. Work will begin soon. Bechtel Corp., 3780 Wilshire Blvd., is engineer and contractor; and Wurdeman & Bechet, 5657 Wilshire Blvd., consulting architects, both Los Angeles.

North Sacramento, Calif.—State Division of Architecture, Public Works Bldg., Sacramento, plans boiler house at new State printing plant at North Sacramento, comprising several large buildings. Entire project will cost about $2,700,000. Wurster, Bernardi & Emmons, 402 Jackson Pl., San Francisco, Calif., and Alfred W. Kahl, 48 Second Ave., San Mateo, Calif., are architects.

Chicago, Ill.—Medical Center Steam Co., recently organized, care of Commonwealth Edison Co., 72 West Adams St., has plans under way for large steam-generating plant at Wood and Taylor Sts., for central-heating service for Illinois and Loyola Universities, and other institutional buildings in Medical Center district. Stone & Webster Engineering Corp., 49 Federal St., Boston, Mass., are consulting engineers. Plant will be operated by Commonwealth company on a non-profit basis. Work scheduled to be placed under way in near future.

Peoria, Ill.—Central Illinois Light Co., 316 South Jefferson Ave., plans expansion in R. S. Wallace steam-electric power plant, with installation of new turbine-generator, high-pressure boiler and accessory equipment for increased capacity. Cost reported close to $8,500,000.

Rushville, Ind.—Southeastern Indiana Electric Co., Rushville, plans rebuilding of local Diesel-electric generating station, recently damaged by fire, caused by an explosion, with loss reported over $400,000.

Henderson, Ky.—City Council has plans nearing completion for new municipal electric light and power plant, estimated to cost approximately $3,000,000, with turbine-generator, boilers, and accessory equipment. Burns & McDonnell Engineering Co., 95th St. and Troost Ave., Kansas City, Mo., is consulting engineer.

Arcadia, La.—Town Council has arranged for purchase of local oil engine-operated power plant from Community Public Service Co., Fort Worth, Tex., and will operate as municipal property in future. Extensions and improvements will be made. Also will acquire waterworks from same company for municipal operation. Bond issue of $500,000, has been authorized for project.

Elizabeth, La.—Calcasieu Paper Co., Inc., kraft paper, plans increase in power plant facilities at mill in connection with a general expansion program in pulp and paper-making divisions, respectively. New production units will be built. Entire project is reported to cost about $5,000,000. H. K. Ferguson Co., M. & M. Bldg., Houston, Texas, is engineer and will supervise construction.

New Orleans, La.—Louisiana Power & Light Co., 142 Delaronde St., plans new steam-electric generating station at Nine-Mile Point, near bridge over Mississippi River, where site has been secured. Installation will include turbine-generator, high-pressure boiler and auxiliary equipment. Estimates of cost are being made.

Shreveport, La.—Universal Oil Products Co., 310 South Michigan Ave., Chicago, Ill., plans steam power plant at

(Continued on page 132)

AT GULF STATES PAPER CORPORATION, Tuscaloosa, Alabama, a Cochrane Atomizing Deaerator of 175,000 lb/hr delivers water of "zero oxygen" content, using water of 50°F. at 50 psi from a storage tank. This is one more of the many Cochrane deaerators in use in the great paper industry. • These deaerators are of many types and sizes; of cast iron with caulked joints, or of steel rolled plate construction. They include the familiar tray type, or, like this one at Gulf States, the atomizing type, both of which have their advantages, depending on conditions. Either can be designed to give complete oxygen removal ("zero oxygen") under the same conditions. • Cochrane, manufacturers of tray type, jet-tray type or atomizing type, can advise with authority on the type best suited to your particular problem.

COCHRANE CORPORATION
3123 N. 17th Street, Philadelphia 32, Pa.

Inquiries will be welcomed. Publication 4160, "Cochrane Atomizing Deaerators", is a clear, unbiased discussion of the advantages of the atomizing deaerator. Publication 3005 discusses all types of Deaerators with particular emphasis on the tray type. Ask for either or both.

Side view of Cochrane Atomizing Deaerator

HOMOPOLAR GENERATOR

(Continued from page 71)

of the annular cooling cavity under the lower collector ring. Similar radial holes connect the upper portion of this cavity with the center hole. Because water rises when it is warm, the water in the cavity is forced inward through the upper radial holes by the incoming cool water. The same process takes place in the upper collector ring. From this point, the warm water is discharged by being thrown by a slinger ring or disc located at the top of the shaft into a collector and thence into the drain.

Through water-cooling the brushes and rings, the problem of dissipating heat is solved. This results in better performance, lengthens brush life, and minimizes collector ring maintenance.

With these improvements the homopolar generator should bring to industry another source of low-voltage, high-current power with these outstanding advantages: 1—A source of pure direct-current power. 2—More amperes per square foot of floor space. 3—Lower first cost. 4—Less operating cost. 5—Reduced maintenance.

With very little change this 21,000-amp, 18.7-v machine for Carnegie Tech could be made to deliver 100,000 or more amperes at low voltage for electrochemical work. The size of a homopolar generator is proportional more to the voltage developed than to its current capacity.

Shaft Currents in Alternating-Current Machinery

Causes of shaft currents . . . Effect of dissymmetries in rotor and stator . . . Shaft currents in induction motors and synchronous machines . . . Electrostatic voltages . . . Methods of eliminating shaft currents . . . Determining the presence of shaft currents . . . Rules for design and operating engineers in the reduction of shaft currents

By **O. E. OLSON**, Electrical Engineer, Electric Machinery & Mfg. Co.

SHAFT CURRENTS usually result from one of the following causes: First, ampere-turns that link the shaft induce flux through the shaft. Second, alternating flux linking the shaft induces currents along the shaft. These currents flow through the shaft, the bearing, the frame or foundation structures, and then through the other bearing to make a complete circuit.

Shaft currents resulting from the first cause stated above are associated with direct current machines where armature current may make an uncompensated turn around the shaft. They are not found on alternating current machines in sufficient magnitude to cause the induction of flux through the shaft since only the field current may link the shaft.

Effect of Dissymmetries in Rotating Machines

The type of shaft currents resulting from alternating flux linking the shaft may exist in either alternating current or direct current machines. The alternating flux is caused by small dissymmetries in the magnetic circuit. The major cause of dissymmetry in alternating current machines is the spacing of the joints between segmental punchings and/or the splitting of frames unsymmetrically with respect to the number of poles. The effect of segments in both rotor and stator is a resultant shaft voltage equal to the sum of each member acting alone. The component of shaft voltage, due to dissymmetries in the rotor, is induced at slip frequency; therefore, it will usually be small in comparison to the shaft voltage induced at fundamental frequency by dissymmetries in the stator magnetic circuit.

A second cause of dissymmetry in the magnetic circuit of an alternating current machine occurs when the machine has an odd whole number of slots per pair of poles. A third is the use of any unsymmetrical number of key slots, with respect to the number of poles, in complete circle type punchings. Axial ventilation holes through the core of the alternating current machine are another source of dissymmetry, unless they are so located as to preserve perfect symmetry with respect to the poles. Unequal air gaps, due to eccentricity to rotor relative to stator, will cause dissymmetry in the magnetic circuit, thereby causing shaft currents in the alternating current machine.

Alternating current machines may have shaft currents for reasons other than dissymmetry in the magnetic circuit. For instance, manufacturing variations will produce shaft currents. Such variations tend to increase with the size of the machine and tend to have greater effect as the number of poles is reduced. Induction motors are much more likely to have shaft currents than synchronous machines because the ratio of ampere-turns required for the air-gap to total ampere-turns is larger in synchronous machines. If the rotor winding of a machine is accidentally grounded to the rotor cores, the whole rotor will be raised to the potential of the winding. Then when the rotor circuit is grounded, as through the bearings, a short circuit current will flow which may cause pitting of the bearing and/or shaft. Finally, electrostatic voltages between shaft and bearings may be set up either by the friction of a belt or a pulley, by rubbing friction within the bearings themselves, or by reason of the potential of the rotor winding above ground. Although the above mentioned external sources could produce shaft cur-

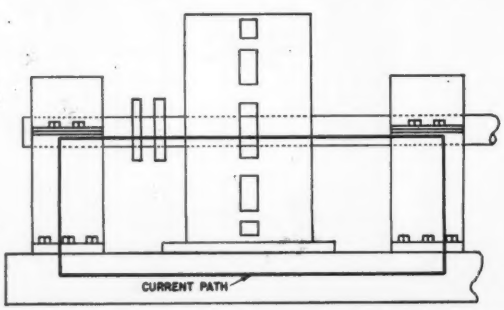

Fig. 1. Diagram of a rotating electrical machine showing the stray current path

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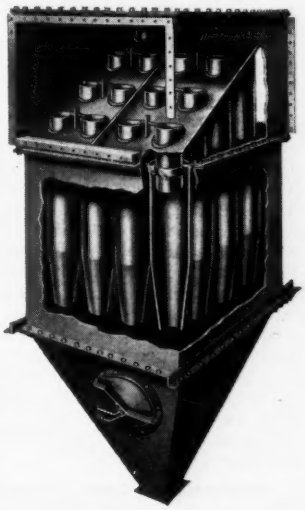
Then consider this fact... Any *one* of these advantages is sufficiently important in itself to make Multiclone equipment the logical choice for your recovery operations. But when you realize that the Multiclone offers definite, clear-cut advantages on *every* qualification essential to maximum efficiency and economy in recovery operations you have some idea of the far-reaching savings you will make by installing Multiclone.



Let us give you further information on Multiclone recovery equipment. A letter, wire or phone call to our nearest office places the information in your hands without obligation. Get *all* the facts—and you'll get Multiclone!

A Few of *Many* MULTICLONE Advantages!

POINT 1 —It Saves Space!

Plant space costs money. Because the Multiclone makes *really important* savings in space, it makes similar savings in plant costs. The chart tells only part of the story because, in addition to being far more compact both in square and cubic footage, the *shape* of the Multiclone can be adjusted to fit various space requirements—either long and narrow, short and wide, or square. You can often fit the Multiclone into tight spaces or waste areas too small for other equipment!

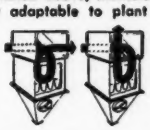
Make	Relative Space Requirements In Sq. Ft.	In Cu. Ft.
Multiclone	1.0	1.0
Collector A	2.1	1.8
Collector B	5.9	3.2
Collector C	6.8	3.9

POINT 2 —It Recovers the "Fines"!

Because its exclusive vane design and small diameter tubes generate higher centrifugal forces, the Multiclone recovers a large percentage of even the very fine particles 10 microns and less as well as the heavier particles. Multiclone's high recovery of both small and large particles means high overall collecting efficiency.

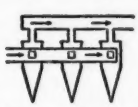
POINT 3 —It is Unusually Adaptable!

In addition to the shape adaptability outlined above, Multiclone's inlet-outlet connections are also readily adaptable to plant restrictions. Where headroom is low, install the Multiclone with side-inlet, side-outlet. Where side clearances are small, use side-inlet, top-outlet arrangement. Or still other arrangements are possible!

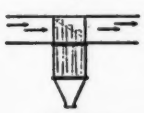


POINT 4 —It is Simple!

Both installation and maintenance of the Multiclone are unusually simple. For example, the Multiclone requires only a *single* inlet and a *single* outlet duct compared with the complicated multiple ducts of conventional cyclones. This not only saves space—but is simpler and cheaper to install and insulate. Moreover, the Multiclone has no filters to replace, no high-speed moving parts to maintain, nothing to require frequent cleaning or repair... and a *single* collecting hopper serves many tubes!



Conventional Cyclone



Multiclone

POINT 5 —Still Other Advantages!

The above advantages are by no means the complete story on Multiclone savings. Get *all* the facts before you decide on *any* recovery installation.

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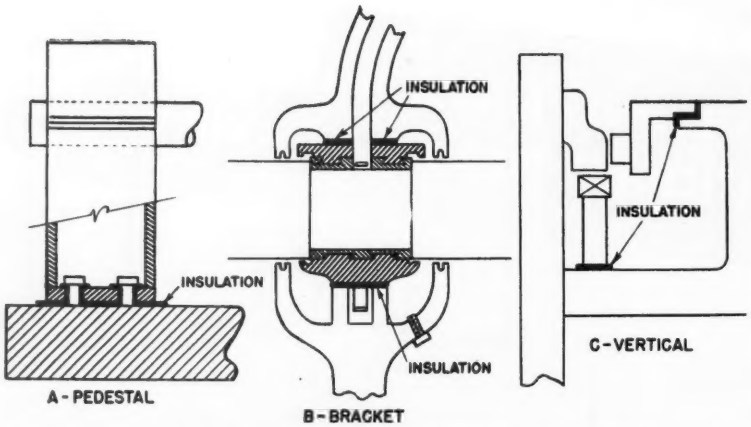

Fig. 2. Drawings showing methods of eliminating shaft currents by use of insulation installed at correct locations on various types of bearings

rents, they are quite rare in industry.

Why Bearing Surfaces Are Affected

None of the foregoing causes necessarily result in bearing currents which are detrimental. There is evidence to show that in a well-fitted sleeve bearing the oil film impedance is sometimes sufficient to prevent the flow of currents even though the conditions are favorable. However, the sleeve bearing fit is usually sufficiently imperfect because there are minute high spots where metal to metal contacts occur. Current flows at the instant of contact and if the current is sufficient, the babbitt is melted and a crater formed. Since this accentuates the high spot of the babbitt, contact at the same spot is more probable. If enough babbitt is built up above the bearing surface, the journal will start to wipe. From then on the deterioration of the sleeve bearing is usually rapid. The ball bearing machine is more likely to have shaft currents than the sleeve bearing machine because the contact between the bearing and the shaft is extremely good. This good contact of the ball bearing machine allows more current to flow for the same shaft voltage. Therefore, the amount of shaft current allowable must be smaller for ball bearing machines than for sleeve bearing machines.

Elimination of Shaft Currents

The elimination of shaft currents is most effectively accomplished by breaking the circuit in which the shaft currents flow. On pedestal-type machines shaft currents may be avoided by insulating the bearing pedestal opposite the coupling from the bed-plate. This includes insulating the holding down bolts, oil piping, grounded connections, and dowels. Insulating the brackets on bracket-type machines is more difficult than the insulating of the pedestal on pedestal-type machines. It is usually accomplished by placing insulation between the bearing opposite the coupling and the bearing housing. In vertical machines, insulating materials are placed between the guide bearing support or housing and the upper bracket. Insulation is also placed between the thrust bearing and the upper bracket. On engine-type machines where the outboard bearing is furnished by the Diesel engine or compressor builder it is the responsibility of the said builder to insulate the outboard bearings.

Shaft currents may be reduced by shunting most of the current out of the bearing. This may be accomplished by adding brushholders, with brushes that ride on the shaft, to the bearing pedestal or bracket. Brushes for this application must have a very low resistance since the resistance of the brushes must be much less than the resistance of the bearing oil film. Metal graphite brushes with high copper content are suitable for this use if the shaft currents are not too excessive. Normally, the contact drop of the brushes is so great that one-third to one-half the original current may still flow through the bearings. To improve this condition an Allgemeine Electricitaets - Gesellschaft (A.E.G.) patent proposed to connect the primary of a transformer across the brushes — the secondary to be wound around the core of the machine. By proper arrangements the voltage applied across the brush may be made to approximately oppose and cancel the line frequency component of the shaft voltage.

Determining Presence of Shaft Currents

To determine the presence of shaft currents in a very simple manner is to short-out the bearing. This may be accomplished by placing one end of a short, large diameter cable against the machine frame or bearing house and the other end against the rotating shaft. In making and breaking contact with this cable an electrical sparking effect will be observed if shaft currents are present. However, this method of testing for shaft currents will not in itself show if there are shaft currents of sufficient magnitude to damage the bearings. A simple method of obtaining comparable readings of shaft current may be accomplished by shorting the ends of the shaft by means of a large cable and then measuring the amount of shaft current by a clamp-on ammeter. A complicated method of determining with greater accuracy the magnitude of shaft currents is by use of a magnetic oscillograph. With the more accurate measurements of shaft currents, it is still difficult to determine the amount of possible damage to the bearings. The amount of damage to the bearing is dependent on several variable factors, such as, the magnitude of shaft current. surface condition of the bearing and the journal. condition of the oil in a sleeve bearing machine, bearing load, and the frequency of the shaft current.

The bearing which has had bearing currents of detrimental magnitude is usually characterized by localized annular fine pit marks. When the bearing becomes pitted, the trouble quickly spreads as these irregularities in the bearing surface tend to increase the arcing effect. In the field. operations are usually carried on so that the bearing is injured to such a degree that it is impossible to study the effect of the shaft current on the bearing. However, the shaft will usually indicate the presence of shaft currents by minute craters with raised sides.

In conclusion, it can be stated that there should be no bearing failures due to shaft currents if proper precaution and maintenance is observed. The design engineer can reduce the possibility of shaft currents by his own experience and by the use of rules stated by Alger and Samson. The manufacturer can reduce shaft current by procuring homogeneous materials which are used in the construction of the machine. If shaft currents are produced even after these precautions are taken, the manufacturer should insulate the bearing opposite the coupling, thereby breaking the path of shaft current flow.

The operating engineer should keep the insulation which is used to eliminate shaft currents clean and in good condition. He should also take care that the insulation is not shorted either by the addition of new construction or by accidentally placing a short across the insulation.

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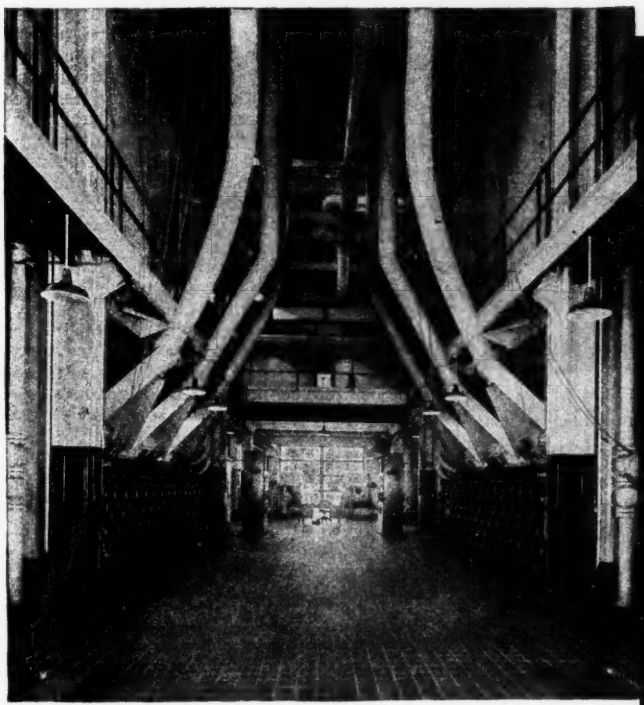

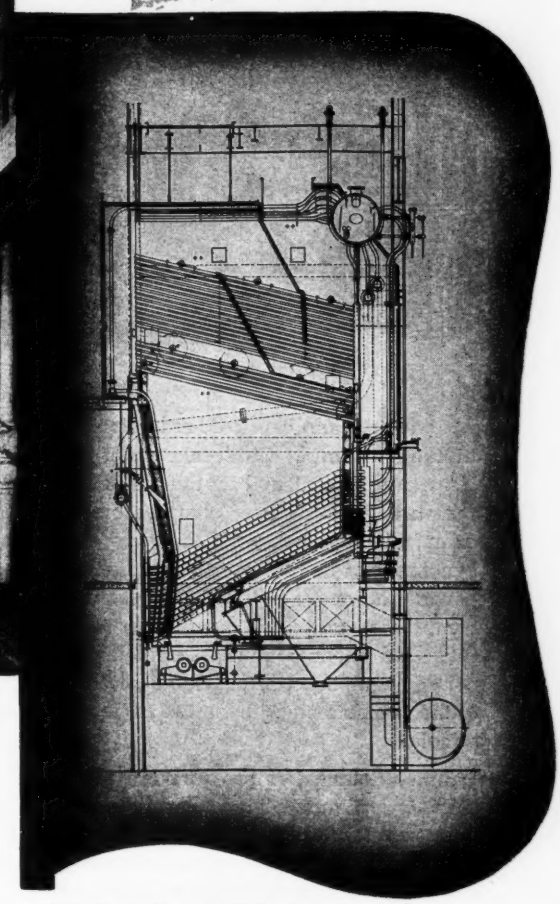

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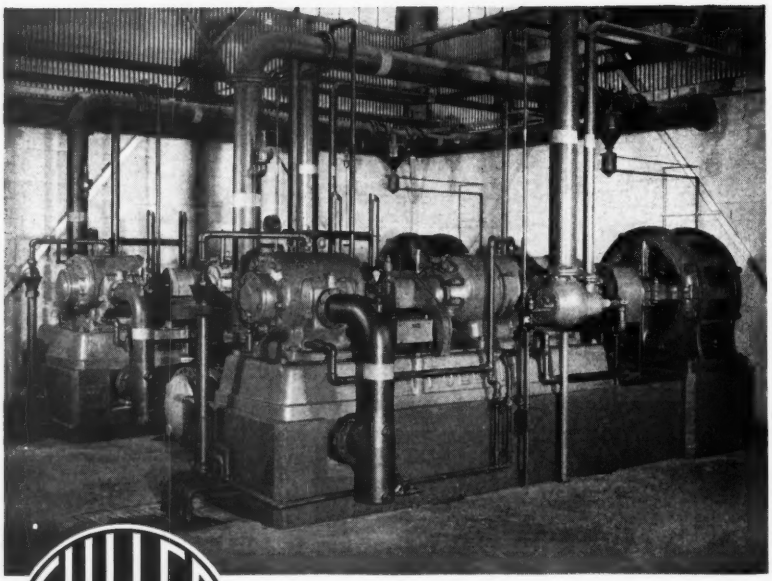

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TWIN BRANCH

(Continued from page 59)

former. A spare 3-phase transformer may quickly be connected to replace any of the three forced oil, forced air cooled transformers serving the two generators of Unit 5.

The step-up transformers, solidly interconnected on their high sides, may be connected with either of two 132-kv buses by bus-selector oil circuit breakers. All 132-kv breakers are rated at 5,000,000 kva (rupturing capacity). They will trip a short circuit within 3 cycles of the time the trip coil is energized, and reclose to restore service within 20 cycles of the initial tripping impulse.

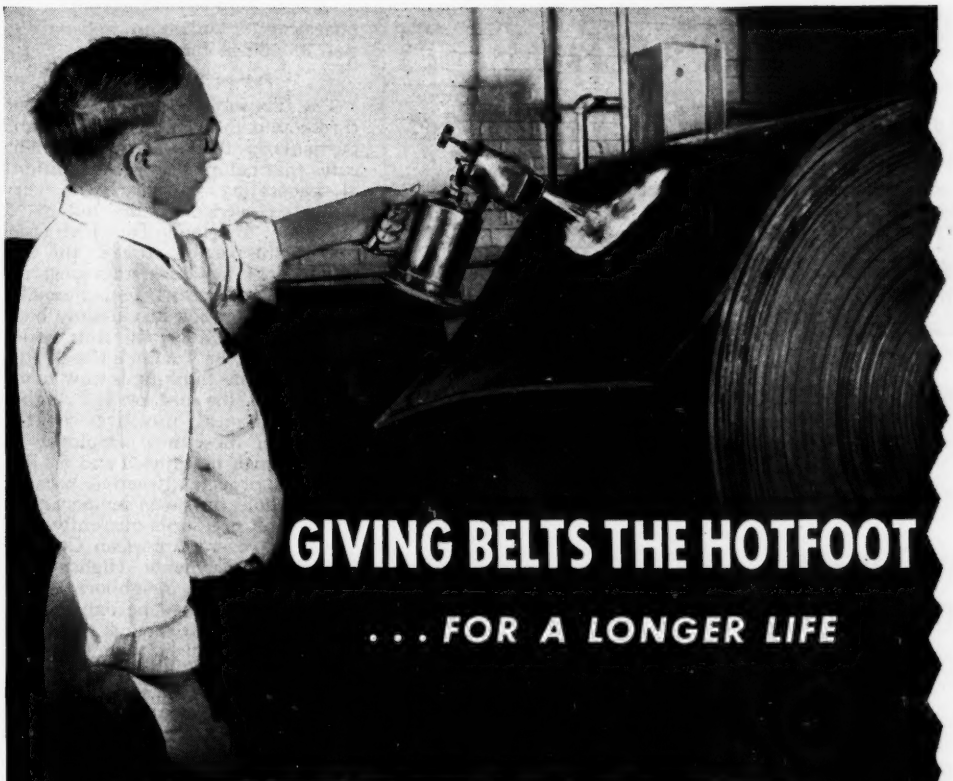
Power for Unit 5 auxiliaries is furnished by two-step-down transformers, one connected to each set of the low-pressure generator leads. These transformers directly feed the 2300-v station buses, from which in turn are fed the 550-v buses through additional transformers. The auxiliary buses may also be connected with the corresponding plant buses for starting or for emergency operation.

Automatic protection against internal trouble in the major electrical equipment, and against any trouble between generator neutrals and transmission lines is provided by differential relays similar to those employed on Unit 3. Lightning arresters are installed on the 132-kv buses and on the high side of the main transformers. Surge arresters are provided on each generator lead. Carrier-current relay protection is used on the transmission circuits.

Centralized Control Room and Automatic Controls

Comprehensive, coordinated and centralized controls are used for boiler, feedwater, turbine, and generator, incorporating features which have proven so successful at the Tidd Plant of The Ohio Power Co. In the central control room, all operating information is indicated and recorded, and all operating adjustments not covered by automatic controls can be made promptly by remote control with full knowledge of related conditions at all times. Consequently it is anticipated that the relatively high efficiency and performances indicated by the heat balance diagram should be attainable not only under special test conditions, but also during normal operation. Controls on both the centralized boiler and turbine control boards permit shutting down any and all units from each location. Auxiliaries are interlocked for proper sequential operation. An unusual feature of this control system are television screens which give the operators a direct view of the boiler water level and of the flames at the burner throats.

There is no doubt that in this case the incremental cost of centralized control over decentralized control is warranted by the simplification of



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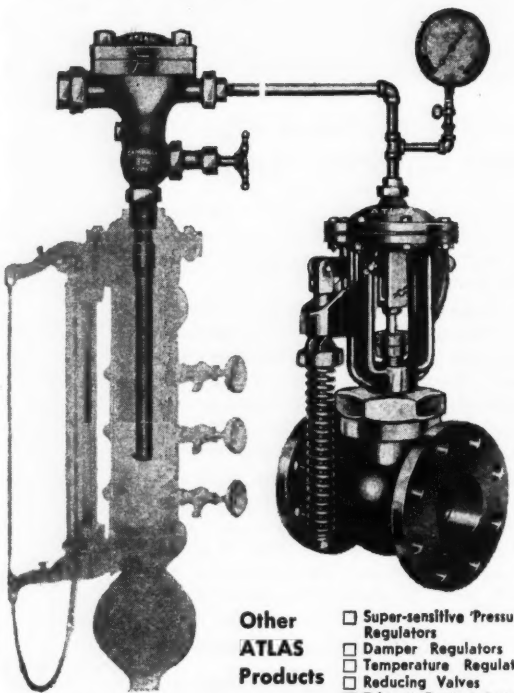

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Future Developments

The continued growth of load throughout the Central System, and particularly the western end, indicates that before very long additional generating capacity will very likely be needed on the Indiana & Michigan division. The high fuel cost in this region stresses the importance of installing the most efficient equipment commercially available. Mention has already been made of the 137,500 kw unit under construction the Tanner's Creek site.

Engineering thinking is now tending toward the use of still higher temperatures at pressures in the vicinity of those now employed at Twin Branch in Units 3 and 5. Reheat has proven attractive because of limitations on steam temperatures at the high pressures currently employed in recent American Gas and Electric developments. Higher temperature, in the neighborhood of 1200 to 1300 F, may be expected to permit the design of high efficiency steam cycles using straight-through machines without reheat.

Certainly, current and future gas turbine developments can be expected to contribute much toward the realization of higher temperatures in steam-electric generating practices. These new developments, coupled with the previous experience of American Gas and Electric engineers in high-temperature and high-pressure installations definitely point to the possibilities indicated above.

Design and supervision of construction of Twin Branch Unit No. 5 was carried out by the American Gas and Electric Service Corporation under the direction of Mr. Philip Sporn, President.

COMING EVENTS

NSPE—A generous share of Texas hospitality is assured for the delegates to the Annual Meeting of the National Society of Professional Engineers at Houston, December 8, 9 and 10, General Arrangements Chairman, Mason G. Lockwood, has announced.

ASME—1949 Annual Meeting of The American Society of Mechanical Engineers to be held at the Hotel Statler, New York, Nov. 27-Dec. 2.

AICE—The Annual Meeting of the American Institute of Chemical Engineers to be held at the Hotel William Penn, Pittsburgh, Nov. 6-10.

SNAME—The 57th Annual Meeting of The Society of Naval Architects and Marine Engineers will be held at the Waldorf-Astoria, New York, Nov. 9-12.

SESA—Society of Experimental Stress Analysis Annual Meeting to be held at the Hotel New Yorker, New York, Nov. 30-Dec. 2.

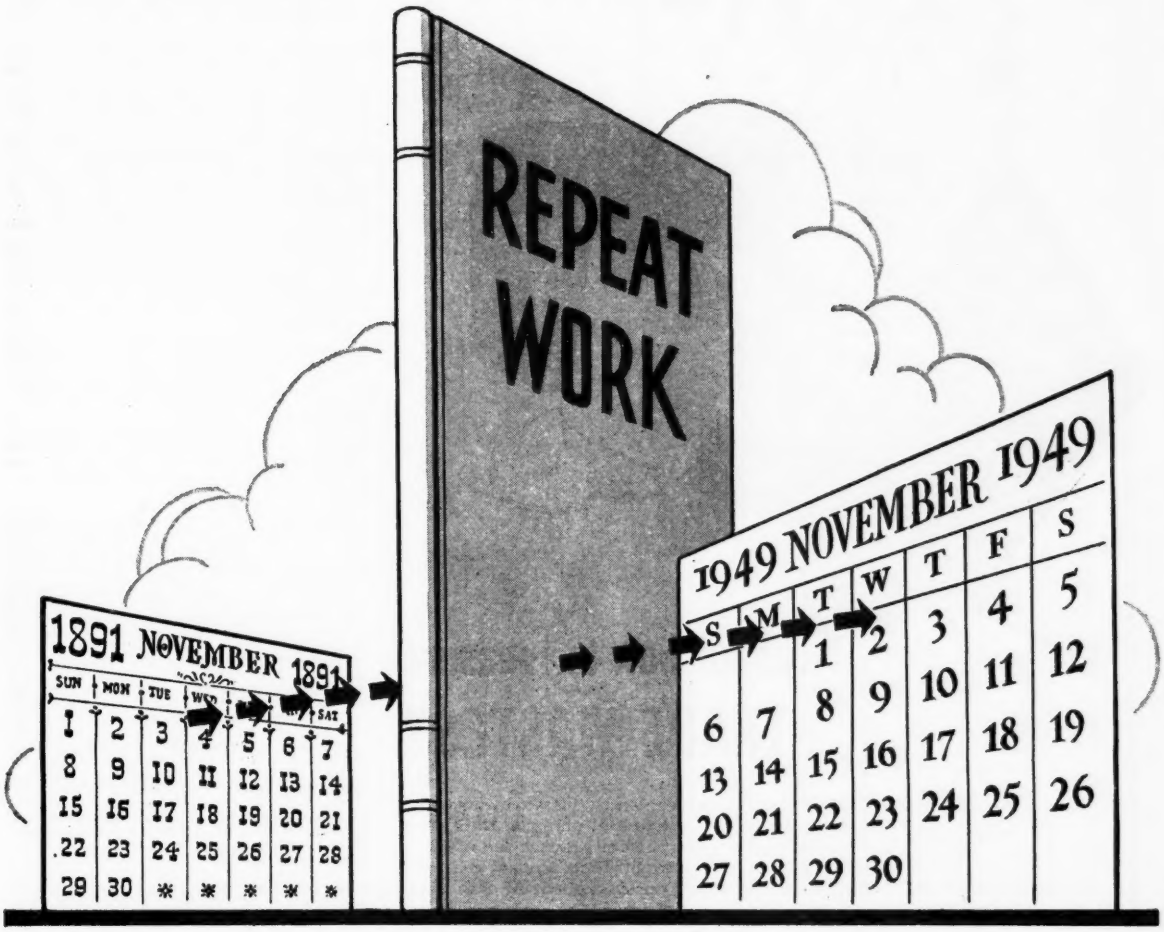
ASRE—The American Society of Refrigeration Engineers will hold its 45th Annual Meeting at the Edgewater Beach Hotel, Chicago, Dec. 4-7.

AAAS—American Association for Advancement of Science Annual Meeting to be held at the Pennsylvania Station zone hotels, New York, Dec. 26-31.

CANCELLATION

Midwest Power Show which was to be held at the Navy Pier, Chicago, November 11-16, has been cancelled.

A MEASURE OF SATISFACTION



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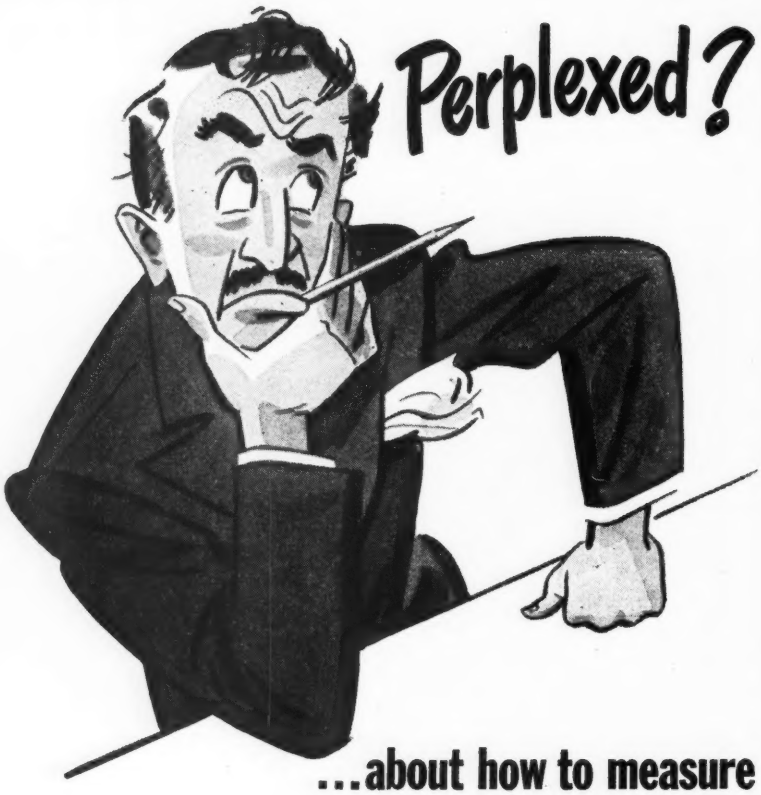

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TRADE WASTES?

In accordance with anti-pollution laws recently enacted by numerous states, most industries now face the task of purifying their plant wastes before discharging them into adjacent streams and rivers.

This purification process usually requires special plant construction, and invariably the necessity exists of obtaining flow data, whether this be the simple indication of flow rate or a more permanent method of recording and totalizing the flow through the plant. With purification processes of this kind, measuring equipment usually is located at the point of discharge of partially filled pipe or in open channels, where low heads or pressures exist and where measurement is either difficult or impossible when using standard forms of measuring instruments.

The Simplex type S Parabolic flume, either alone or in conjunction with a Simplex type HF water float operated meter, is the ready answer to this measuring problem. Compact in design, with no pockets or grooves to catch sediment or solids, and capable of operating under low flow conditions, the unit measures over long ranges, from maximum to 5% of maximum capacity.

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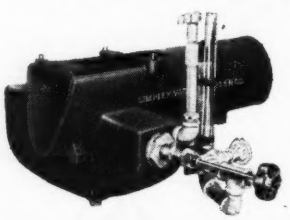

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New ENGINEERING BOOKS

Modern Industrial Construction—A detail reference by Duane F. Roycraft. Size 9¾ in. by 11¼ in. 212 full page detail plates plus index; flexible imitation leather cover. Published by Roycraft Publishing Co. Price $10.00.

In the preface to this volume, the author, an architect, specializing in industrial buildings, states that while material symbolical of good construction is available for the residential and commercial class of structure, no edition at this time specifically treats shop or factory construction in detail form.

The 212 detail plates presented in loose-leaf form are drawn to scale, ranging from ⅛ in. to the foot to the full scale, and may in many instances be removed and reproduced on working drawings with little or or no charge.

Details of particular interest to power engineers are: door and frames 51 plates; stair construction, 26 plates; walls and monitors, 12 plates and such other details as expansion joints; flashing, hatch covers, ladders, louvers, roofs, bins, hangars, showers, etc.

Text is limited to a preface explaining the book, a complete index and table of abbreviations. Plates are printed on one side only and T-slotted for removal and replacement.

• • •

Challenge of the American Know-How, by Pearl Franklin Clark; 172 pages; size 5¼ by 8 in.; cloth binding; published by Harper & Brothers, 49 E. 33rd St., New York 16, N. Y. Price $2.50.

This book, which has received a great deal of attention in the non-technical press, is written by the wife of the famous management engineer, Wallace Clark. It is the story of how Mr. and Mrs. Clark studied at close range the operation of European industrial methods and how they were able to measure carefully the peculiar habits of mind that make it so difficult for Europeans to grasp and apply American managerial and production methods.

The story illuminates the weakness of European industry in dealing with the human problems of management. The author states that in Europe they think there is some magic method by which you can put into operation all the machinery and procedures used in American factories and then sit back in the front office and watch them work miracles.

She shows how this definitely is not the case; for the real secret of the American know-how is in planning from the bottom up. That is, when obstacles occur in the free flow of work, the American management engineer immediately goes right to the work and whenever necessary, if the trouble is not obvious, begins to question the worker himself and try to get his ideas on what is causing the trouble. This is frequently successful and, in the author's opinion, accounts for the differences in results. In other words, it is an attempt to put democracy into action in industry.

Written from the point of view of a woman who was more or less forced into the work to help her husband, and then became fascinated by it and expert in it, told in a pleasant, simple narrative style giving her own personal observations and impressions of European industry, this book is something different from the usual engineering treatment of the subject.

Engineers know that when this type of American planning and management is done, as Mrs. Clark describes it, results are almost invariably successful. There is a great deal of it in this country. It was the fact that Mrs. Clark had not been aware of it that made her so conscious of the reasons why all the European attempts at American methods did not yield results. The Europeans think it is some magic in the American machinery itself. Mrs. Clark shows that the secret is in American men, not their machinery.

• • •

Sources of Engineering Information, by Blanche H. Dalton; 110 pages; size 6 by 9 in.; cloth binding; published by the University of California Press, Berkeley 4, Calif. Price $4.00.

This is a very practical guide to engineering literature and data, designed for engineering students, practicing engineers, research workers and librarians. Its arrangement is based on studies of the use of an actual library and enables the technical man to find the key to many research problems previously published in a par-

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ticular field. The volume covers every type of engineering. Important source material is briefly described and its use explained.

The author is librarian of the engineering library of the University of California and has had wide experience not only in dealing with problems in research work at the University, but also by large industrial and technical firms in the area.

The book contains indexes to periodical and serial literature, references to abstracts of all kinds, then a list of references through which it is possible to locate the official title of journals containing subjects sought and to identify the various periodicals. The fourth chapter is on bibliographies in the various fields and the fifth covers reference books, such as encyclopedias, technical dictionaries, handbook and manuals and manufacturers' directories. There is a chapter on the trade catalog collection and one on standards and specifications.

The book does not, of course, list the specific items you are looking for but tells you how to go about finding them in a given field. It should prove most useful for consulting engineers, research workers and others who need to search thoroughly the literature in a given field.

• • •

Elements of Diesel Engineering by Orville L. Adams, Sr.; Second Edition; 367 pages; illustrated; size 5½ by 8 in.; cloth binding. Published by the Norman W. Henley Publishing Co., 254 W. 54th Street, New York, N. Y. Price $5.00.

Orville L. Adams, who died a few months ago, was the author of the well-known books entitled, Modern Diesel Engine Practice and Diesel Operation and Maintenance. During World War II he served with the United States Navy as ship repair officer in charge of maintenance and repair of a fleet of Diesel powered auxiliary ships. In addition, he taught classes of Army and Navy personnel in Diesel engineering.

After the war, desiring to bring up to date his previously published work under this title, which had been allowed to go out of print during the war, he discovered that what was needed was a completely new book. He scrapped almost 90 per cent of the old material, wrote much entirely new material and so finished this work. He died suddenly while on temporary active duty as a Lieutenant Commander in the Naval Reserve.

The book, therefore, reflects all the progress made in this field since the first edition in 1936. It begins with chapters on Diesel definitions, Diesel engine mathematics and fundamental engine cycles. Then follow discussion of fuel injection systems; combustion and heat distribution; rating, testing and performance; air intake and supercharging. This is followed by interpretation of Diesel indicator diagrams, then a chapter on Diesel fuel and lubricating oils, another on fuel properties and engine performance. In the appendix are tables of nomenclature, units and mathematics, discussions of combustion and heat distribution in the internal combustion engine, fuels, and tests in specifying lubricating oils.

One of the features of the book is the large number of illustrations and simple black and white diagrams illustrating principles, as well as details, of operation. Each chapter is followed by a selection of problems, many to be worked out mathematically to a quantitative solution.

This is one of the best books in the field, for it is devoted to fundamental principles of Diesel engines and not primarily to details of specific makes of engines. The latter are well covered in other recent books and in catalogs of the various manufacturers. While the book is designed primarily as a textbook for class room use, the student working on his own will not find it too difficult for ready understanding. Some knowledge of relatively simple algebra and logarithms is necessary for working the problems, but no higher mathematics is involved.

• • •

The Efficient Use of Steam by Oliver Lyle; 912 pages; illustrated; size 6 by 9½ in.; cloth binding. Written for the Fuel Efficiency Committee of the Ministry of Fuel and Power. Published by His Majesty's Stationery Office, 429 Oxford St., London, England. Price 15s. Net ($3.03).

As we pointed out in reviewing **Power and Process Steam Engineering** by Douglas Copp in the April 1949 issue, page 98, (a book dealing primarily with English practice) coal is the principal source of artificial heat in Great Britain and one of the country's greatest material assets. According to the English, this coal is being rapidly dissipated and must be conserved as much as possible. The days of cheap-

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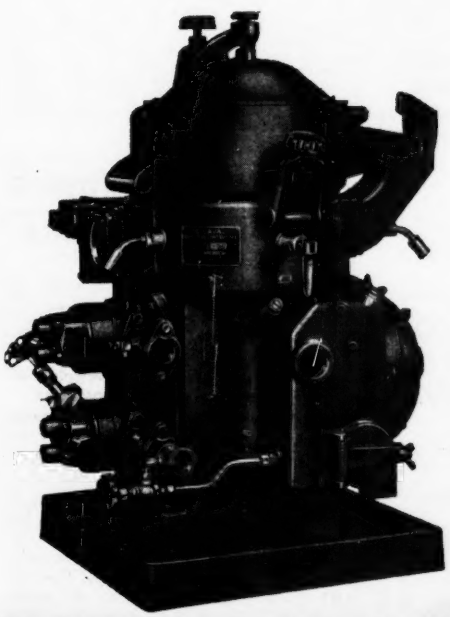

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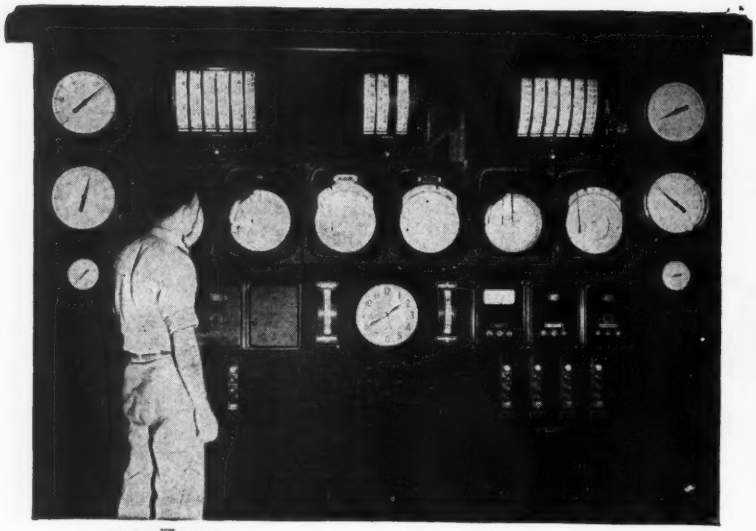

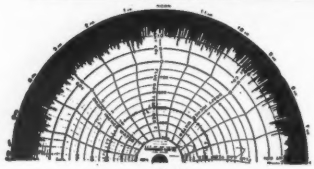

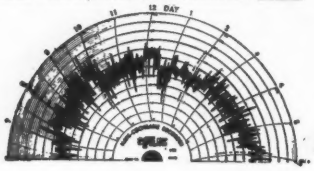

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• Hays operation solved this problem instantly: full automatic operation when burning coal alone—manual operation for burning wood and coal; and only a flip of a switch to change from either method to the other—no complicated linkages to disconnect, no time lost. An average of 70 percent efficiency is maintained, CO_2 averages 12 to 14 percent and the stack is clear.

• If you are seeking to improve steam plant efficiency and reduce fuel costs, look well at this truly modern system. Talk over your combustion needs with Hays engineers—good men to consult. No obligation, of course. In the meantime write for Publication 47-605—you'll find it exceedingly helpful.

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ness and apparent plenty, say English authorities, have passed and all English engineers and industrialists must think more and more of economy of heat utilization. That was the primary purpose behind Mr. Copp's book and it is also the primary purpose behind this very interesting and valuable work.

From the point of view of fuel economy, the correct use of steam for heating and power is of such importance that Mr. Lyle, a member of the Fuel Efficiency Committee of the Ministry of Fuel and Power, was asked by the Committee to write a book to give users of steam in factories the information they need in the most convenient form. This is an intensely practical book, with the necessary minimum of theory, dealing with the design, maintenance and operation of the types of steam plants and accessories used in industry, with the tables and formulas needed for reference by power engineers, plant engineers and works engineers.

Steam, says the author, is industry's most wonderful, flexible, adaptable tool. Yet steam users misuse and ill-treat steam, the beautiful heating and power tool, because they have never learned or been taught how to use and care for it.

Almost everything that needs to be known about steam is in the steam tables—awe-inspiring columns of figures with unappetizing titles. The new knowledge about steam that the war has uncovered is the sad lack, in only too many factories, large and small, of the simple principles governing the economical use of steam. Immense pains are often taken to capture an extra 2 or 3 per cent in the boiler house, yet the factory may be using 2 or 3 times as much steam as is necessary. This book, therefore, is an attempt to gather the essential information to enable steam to be correctly used. So far as possible, mathematics have been avoided, the most advanced mathematics being a pair of simultaneous equations. But there is necessarily a good deal of arithmetic.

The book begins with a discussion of what steam is and its heating properties, then goes into the power properties of steam, how they are measured and how they are shown on various types of diagrams.

There is a good chapter on the important question of flash steam and low pressure vapor. The subject of peak loads and heat storage is covered in considerable detail, so is evaporation, pressure hot water and automatic controls for these.

Investigation of how much heat is being used, and why, leads to the heat balance, which many industrial plants know practically nothing about, either in England or in this country. This is covered in a long and very thorough chapter with many calculated examples. There is no book that deals with the saving of power and no book with the saving of electricity, says the author, so he inserts a chaper on this subject, another on economizers and a very interesting chapter on how to set about steam saving, with many typical examples. In an appendix are all the necessary steam tables, many examples and a list of references, and the book is well indexed.

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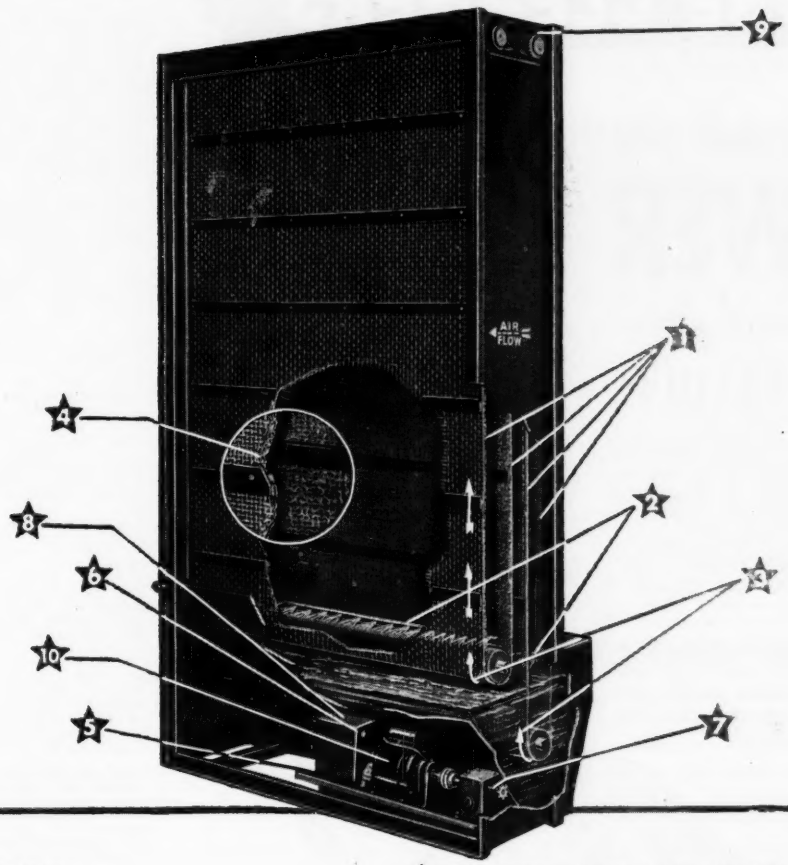

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147 Sussex Avenue Newark 1, N. J.

HELPFUL BULLETINS

(Continued from page 36)

and snatch blocks, as well as drum type car pullers for heavy duty service. Link-Belt Co.

MISCELLANEOUS

129 **Refractories**—Two types of fire brick, one for extra high furnace temperature use, are featured in this 2-pp illustrated bulletin. Describes composition and applications of the refractories. Also includes data on company's high temperature cements, plastics, castables and coatings. Walsh Refractories Corp.

130 **Tube Expanders**—Bulletin 380, 8 pp. covers manufacturer's line of tube expanders for maintenance of high pressure boiler tubes, superheaters, economizers, circulating tubes, steam generators and like equipemnt. Various models are illustrated by photo and described as to application. Also included are engineering drawings to show typical applications of one model. Accessories for tube expanders are also described and illustrated. Thomas C. Wilson, Inc.

131 **Tube Cleaners**—Manufacturer's line of air-driven and water driven cleaners for straight or curved small tubes are illustrated by photo and discussed as to operation and use in 4-pp Bulletin Y-24. Also contains photos of cleaner parts and hose, and includes size tabulation for straight and curved tubes. Lagonda Div., Elliott Co.

132 **Combustion Catalysts**—The use of two catalysts—one a chemical for keeping heat receiving surfaces in the boiler free from the insulation effects of accumulated soot, and the other a liquid oil additive for use in oil-fired boiler furnaces—are explained in 4-pp Bulletin 46. Also describes a hopper device for spraying the chemical catalyst and includes a coal-fired furnace drawing showing an installation of this hopper. National Aluminate Corp.

133 **Preventing Pitting**—"Prevention and Reduction of Cavitation and Pitting in Hydraulic Turbines" is the subject of 12-pp Bulletin 02B7226. Applicable basic formulas are elaborated upon and the relative merits of avoiding cavitation or minimizing its effects are presented. Several examples of pitting, the destructive effect of cavitation are shown and pitting is differentiated from erosion and corrosion. The mechanisms of cavitation and pitting are explained in the light of recent evidence, and the resistance of various special metals to pitting is given and methods of utilizing these metals at critical points to withstand pitting are discussed. Allis-Chalmers Mfg. Co.

134 **Humidifiers** — Illustrated Bulletin 1772, 12 pp, covers manufacturer's line of steam humidifiers, including two new air-controlled models. Includes discussion of dry air problems, tables on desirable relative humidities and regain of hygroscopic materials, complete data on the operation and installation of both electric and air-controlled models. Also tells how to select humidifiers, giving capacities and prices. Lists and illustrates air-operated and solenoid operated valves for use in humidifier control. Armstrong Machine Works.

135 **Blowers** — Bulletin 21-B-37, 8 pp. covers manufacturer's smaller size rotary positive blowers for pressure or suction service. Explains construction features and operating advantages of rotary positive blowers, and is profusely illustrated, including graphs showing operating characteristics under constant, variable and multi-speed operation. All driving arrangements are also illustrated, as are recommended accessories, including pressure and vacuum relief valves, inlet muffler-filters, and straight-flow mufflers, for suction and discharge lines. A selection table covering the capacity and pressure range of each blower size is provided, together with a dimensional drawing giving details on standard sizes. Roots-Connersville Blower Corp.

136 **Cooling Tower Maintenance**—Titled "A Blueprint for Operating and Maintaining Mechanical Draft Cooling Towers," this is a 16 pp handbook. It discusses the application and performance of cooling towers and gives instructions for placing towers in operation. Also discusses cleaning, water distribution system, lubrication, resuming operation after short shutdown or long inactivity, safety factors and economies. Also contains a chapter devoted to general preventive maintenance of mechanical equipment, water basin and

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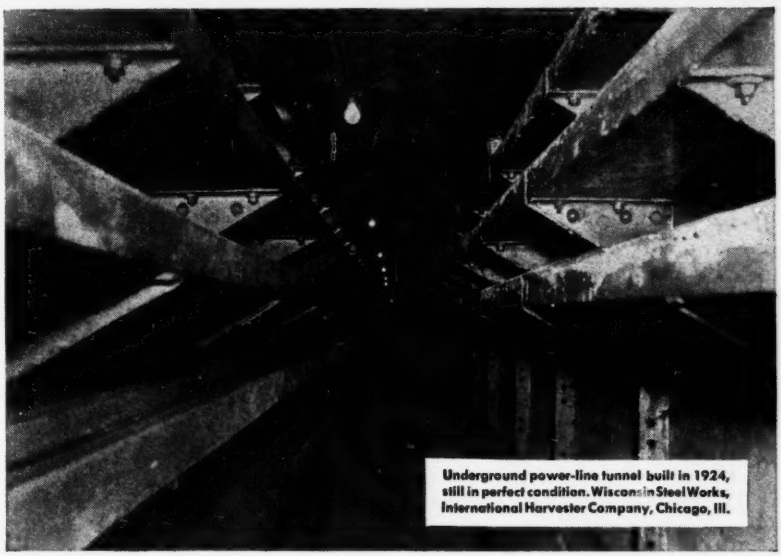

Underground power-line tunnel built in 1924, still in perfect condition. Wisconsin Steel Works, International Harvester Company, Chicago, Ill.

It was 15 degrees below zero when workmen placed Lumnite concrete in the forms for this underground power-line tunnel back in 1924. But despite the below-freezing temperature, Lumnite gained *full working strength* within 24 hours. Today, it's still in excellent condition and continues to give the same strong, durable service it has for 25 years!

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Other Lumnite power plant uses are listed at the left. Depending on requirements, Lumnite provides high structural strength, high heat resistance and low thermal conductivity. Write for free booklets giving complete information on Lumnite for refractory, insulating, corrosion and heat-resistant concrete installations throughout the power plant.

WHERE TO USE LUMNITE IN POWER PLANTS

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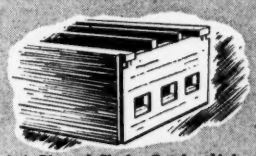
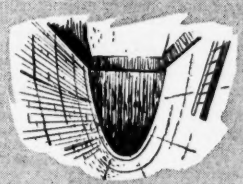
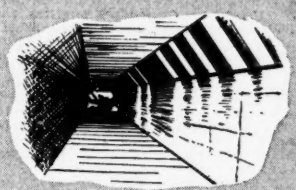


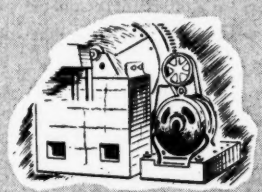
Ash Pit and Cinder Catcher Linings



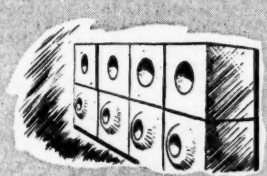
Coal Bunker Linings



Flue and Duct Linings



Overnight Structural Concrete



Castable Refractories

Factory-prepared mixtures of LUMNITE and selected aggregates. Mixed with water on the job, cast into place for door linings, arches, baffles, furnace walls. Special shapes can be cast in molds, ready within 24 hours. Castables to meet different temperature and insulation needs are made by manufacturers of Refractories, sold by their distributors.

*"LUMNITE" is the registered trade mark of the calcium-aluminate cement manufactured by Universal Atlas Cement Company.

PG-L-22

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UNITED STATES STEEL CORPORATION SUBSIDIARY

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WHY DO Genuine BELMONT FLAX PACKINGS Seal Securely and Last Longer?

1 We possess complete facilities for their manufacture.

2 Belmont controls the purchase of the raw flax fibre. It is carefully selected for length, strength and softness.

3 The steps of hackling, spreading and drawing of suitable rovings are all accomplished within the Belmont plant.

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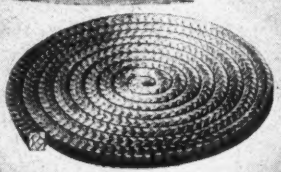
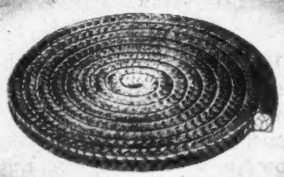
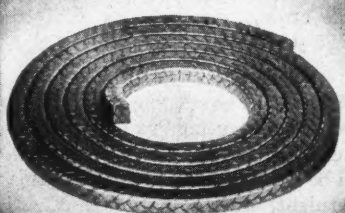
Distributors located in every large industrial center, are ready to serve. Or, write on your company letterhead for catalog No. 40.



BELMONT 401X (Coil or Reel) — Best quality Line Flax Fibre of selected length and strength.



BELMONT 404 (Coil) — Pure flax fibre of next fibre length to Line Flax.



BELMONT 303 (Coil) — Line Flax of selected quality, with course and short fibres extracted. Treated with waterproof lubricant and surface graphited.

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A BELMONT PACKING FOR EVERY SERVICE
Steam, Water, Oil, Gas, Air, Acids, Alkalies, Ammonia ◆ Rings, Spirals, Coils, Reels, Spools, Sheets, Gaskets

distribution system, and structure. Illustrated with photos, sectional drawings and sketches. C. H. Wheeler Mfg. Co.

137 **Hoisting Towers**—Tubular steel towers for heavy and light duty hoisting service are described in this 4-pp bulletin. Sketches showing tower assembly and parts and illustrating construction features are included. Gives load capacities of both types, lists optional equipment. Manufactured by Beaver Art Metal Corp., Distributed by Dravo Corp.

138 **Steam Condensers**—Twelve-pp Bulletin 5A is devoted to low level multiple jet condensers, describing their advantages and applications in connection with turbines, engines, and process equipment of power stations and manufacturing plants. Gives sizes and capacities available, operating instructions. Also includes phantom illustrations of the condensers and colored drawings showing standard and special arrangements with turbines, reciprocating engines. Table shows properties of saturated steam temperature as independent variable. Schutte and Koerting Co.

139 **Magnetic Separators**—Eight-pp illustrated Catalog C-5000A describes electric and non-electric magnetic pulleys, non-electric magnetic drums, triple pole rectangular magnets, lifting magnets, non-electric plate magnets, high intensity induced roll and cross belt magnetic separators and related equipment. Data includes brief specifications, applications and features of the equipment, which is designed for use in the removal of tramp iron to protect crushers, grinders and other machinery, and for purification of magnetic minerals from non-magnetic minerals. Dings Magnetic Separator Co.

140 **Diesel Engines**—Featuring company's opposed-piston Diesel engines rated at 4,000,000 hp installed, Bulletin 3800D-1, 20 pp, is lavishly illustrated with photos, engineering drawings and full-color sectional illustrations. Discusses in detail the engines' crankshaft and vertical drive, cylinder block, cylinder liners, connection rods, bearings and pistons, fuel system, fuel injection system, lubricating system, cooling system and other design features. Dimensions included. Fairbanks, Morse & Co.

141 **Speed Reducers**—This 8-pp booklet presents actual case histories showing how installation of company's worm gear speed reducers effected savings in space, weight and money. Includes photos of available models. The Cleveland Worm and Gear Co.

142 **Spray Welding**—This 4-pp booklet describes manufacturer's powder metallizing gun, and the spraying of three powdered alloys as well as other powdered metals, such as brass, copper and zinc. It is pointed out that the gun can be used for metallizing as well as for manufacturer's own process which combines both welding and metallizing. Several of the hard facing applications which have proven most adaptable to this process are included. Numerous photos illustrate the gun, the process, and a few applications. Wall Colmonoy Corp.

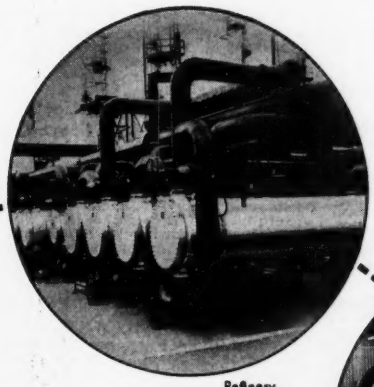
CATALOG LIBRARY

This monthly list of the latest standard catalogs and bulletins is designed to aid the engineer in maintaining his permanent catalog file of engineering data. The items listed, unlike those under Helpful Bulletins, will appear each month except for additions and deletions determined by space requirements or by the manufacturers issuing the bulletins. Use the Helpful Bulletins coupon in requesting these copies.

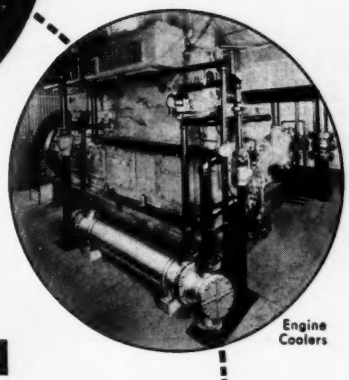
BOILERS AND AUXILIARIES

201 **Working Pressure Data Card**—Maximum allowable working pressures for water tube and fire tube boilers are compiled in a handy reference table, Technical Data Card No. 113 A. It lists pressures in pounds per square inch for seamless and electric resistance welded

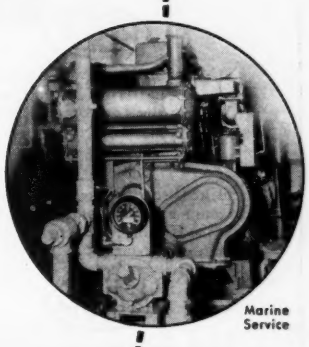
Surface Condensers



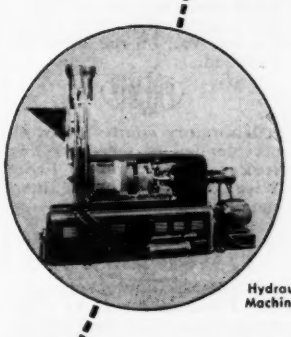
Refinery Exchangers



Engine Coolers



Marine Service



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YOU'LL GET JOB-MATCHED PERFORMANCE FROM THESE STANDARDIZED EXCHANGERS

For a big 27,000 sq. ft. surface condenser down to a little 2-inch oil cooler, Ross standardization today means new highs in job-matched performance and new lows in unit costs.

You may be outfitting a power plant, a petroleum refinery or a chemical plant requiring large capacity heat exchanger equipment . . . or you may be selecting smaller exchangers as accessories for the Diesels, compressors or hydraulic equipment which you use or make for sale to others. Neither the size, nor the type of service, nor the operating conditions present a challenge to Ross standardization . . . for Ross has standardized *successfully* on practically everything that is required in heat exchanger equipment.

This means, naturally, that the time-robbing, cost-mounting aspects of custom fabrication are avoided wherever Ross standardization suffices . . . and it more than suffices in most instances. But, where it doesn't, you still have available the industry-leading experience in special engineering and custom fabrication for which Ross has been known some 30-odd years.

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★ **PREVIEW ROSS STANDARDIZATION** by requesting free Bulletin 4300, then review it with a Ross engineer who will gladly consult. ROSS HEATER & MFG. CO., INC., Division of American Radiator & Standard Sanitary Corp., 1428 West Ave., Buffalo 13, N. Y. In Canada, Horton Steel Works, Ltd., Fort Erie, Ont.

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AMERICAN STANDARD • AMERICAN BLOWER • CHURCH SEATS • DETROIT LUBRICATOR • KEWANEE BOILER • ROSS HEATER • TONAWANDA IRON

carbon steel tubes or nipples for different diameters and gages of tubes conforming to ASME specifications. Chart covers 2 letter-size pages, is printed on firm stock, and punched for use in binder. The Babcock & Wilcox Tube Co.

202 **Blast Furnace Gas Burner Bulletin**—Said to be the first published on the subject. Bulletin No. 500, 4 pp, describes operation of these burners and discusses their adaptability for use not only with waste fuels, but also in combination with auxiliary fuels and by means of auxiliary fuels alone. Contains pictures of gas burner installations and cross section drawings of various other types of burners for waste and primary fuels. Peabody Engineering Corp.

203 **Steam Generating Equipment**—Bent-tube and straight-tube boilers of several classes are described in detail and illustrated by photos and drawings in this 4-pp bulletin. Also illustrated are some of the valves, heat transfer equipment and refrigeration equipment manufactured by company. Henry Vogt Machine Co., Inc.

203A **Water Tube Boilers**—This 12-pp bulletin illustrates and describes special and standard power plant boilers and packaged steam generators. Includes data and dimensions. Springfield Boiler Co.

VALVES, TRAPS, PIPING

204 **Pipe Distribution System Data** — "Engineering Distribution Data for Underground Steam Distribution," is the title of Section 480-2, 34 pp, of practical usefulness to those who deal with problems involved in insulated piping distribution systems. It covers layout of the route and methods of estimating steam loads, includes steam flow charts and tables, and gives properties of steel pipe, copper water tube piping and saturated steam. Also gives specifications of steam and hot water distribution piping with prefabricated pipe conduit. It's illustrated with photos of field installations and industrial applications of insulated pipe units, also sketches showing method of making field closures. The Ric-Wil Co.

RODA

High grade gas, by-product and steam coal from Wise County, Va., on the Interstate Railroad.

CRITERION COAL

High grade gas, by-product, steam and domestic coal—Pittsburgh seam from Irwin Basin, Westmoreland County, Pennsylvania, on the Penna. Railroad.

PENDRON

High grade gas, by-product, steam and domestic coal from Wise County, Va., on the Interstate Railroad.

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Genuine Pocahontas from McDowell County, W. Va., on the Norfolk & Western Railroad.

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High grade, high volatile steam and by-product coal from Wise County, Va., on the Interstate Railroad.

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High fusion coking coal for by-product, industrial stoker and pulverizer use from Wyoming Co., W. Va., on the Vgn. Ry.

PREMIX

A laboratory controlled product blended to meet exacting stoker requirements. From Wise County, Va., on the Interstate Railroad.

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Hazard No. 4 and No. 7 steam and domestic coal from Wiscoal, Knott County, Kentucky, on the L. & N. Railroad.

GLENBROOK

The Premium Kentucky High Splint unmatched for domestic use. Produced in Harlan County, Kentucky, on the L. & N. Railroad.

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CINCINNATI NEW YORK NORFOLK PITTSBURGH

205 **Piping Materials Catalog**—Corrosion resistant valves and piping materials are covered in illustrated circular No. 320, 32 pp. Contains information on manufacturer's complete line of valves, fittings, fabricated piping and pipe coils to meet a wide range of corrosive conditions. Listing includes both photos and cutaway drawings of models, complete specifications, sizes and prices. Includes a description of alloy metals used and a corrosion questionnaire. Also included are several pages of condensed recommendations on the selection of piping materials according to service requirements as well as a pictorial chart showing basic types of valves with names of their component parts. Crane Co.

206 **Steam Specialties**—Here is a collection of bulletins covering manufacturer's line of thermostatic steam traps, inverted bucket steam traps, float-thermostatic steam traps, radiator traps and valves, alternating receivers and lift traps, self-operated temperature regulators, air venting equipment, water blenders, strainers. All equipment is illustrated by photos, its operation and applications discussed, and its capacities, dimensions and prices listed. Sarco Co., Inc.

207 **Pipe Hanger Catalog** — Ninety-page Catalog 10-D is a valuable buyer's guide for adjustable pipe hangers and supports. Covers hangers for attachments to pipe and to structure, hanger assemblies, spring hangers, hanger rods, pipe supports and related equipment. Each type described and illustrated by photo and dimensional diagram and listed with dimensions and prices. Catalog also includes standard specifications, photos of installations and terms of sale. Indexed for quick reference; punched for filing in binder. Grinnell Co., Inc.

208 **Valves Bulletin**—A new catalog section 12-H describes all types of the company's cast steel pressure-seal bonnet valves. Information on choosing the best size valve for your service is given in one page of the booklet under the title, "Correlation of Valve Size and Pressure Drop." Design and construction advantages of the valves are given and tables of pressure and temperature ratings. Details of design including operating mechanism, body design, disk piston, and other features are explained. Dimensional details are given in tabular form accompanied by dimensioned line drawings. A standard materials specification table is presented. Edward Valves, Inc.

209 **Rubber Expansion Joints** — This 8 page bulletin AD 137 tells about the application, construction, styles, service and advantages of the company's line of rubber expansion joints. Other information given, includes "How To Order" and a table of dimensions which is accompanied by dimensioned line drawings. The bulletin is well illustrated. The Garlock Packing Company.

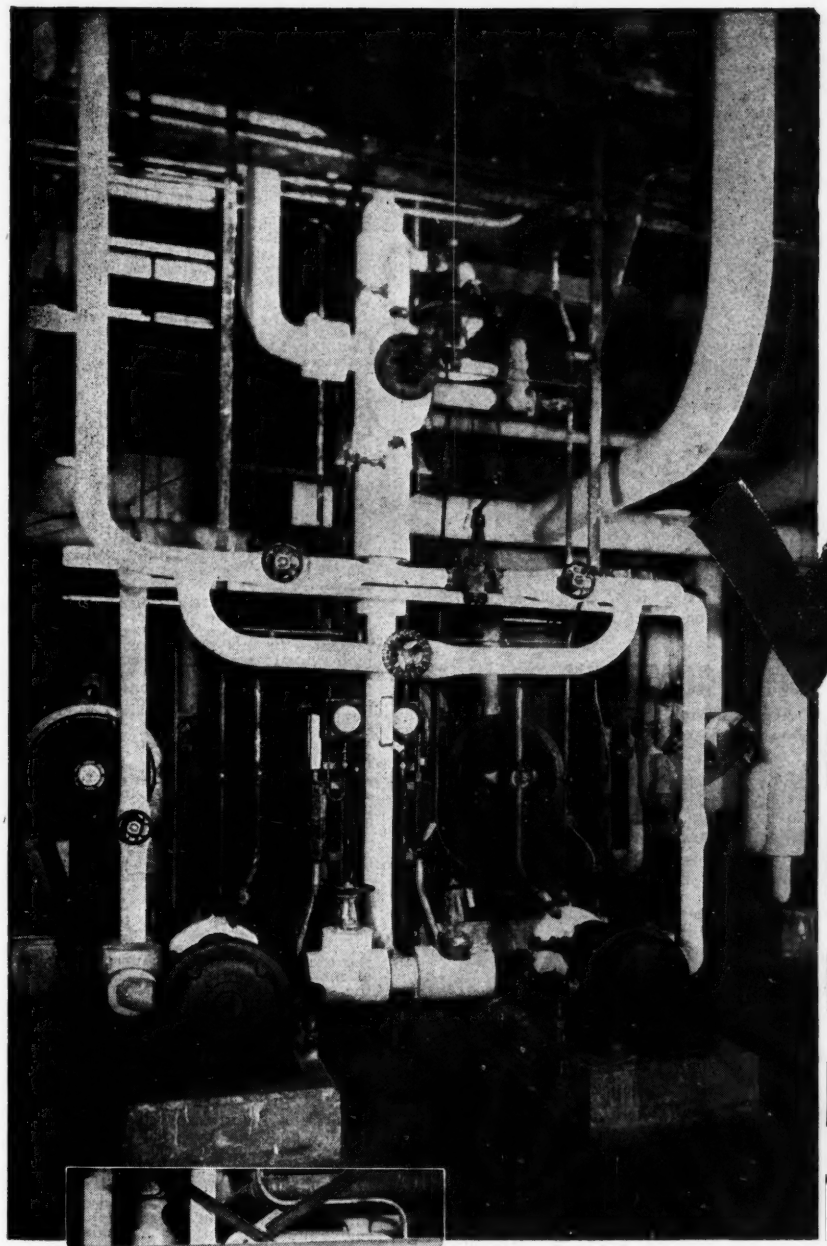
210 **Control Equipment**—General Catalog 001, 30 pp, is devoted to measuring and control equipment for water and sewage works, power and processing industries. Catalog illustrates and describes in detail: venturi tubes and meters, controllers, gages, manometers, pitot equipment. Includes capacity tables, dimensional data, specifications, layout drawings. Simplex Valve and Meter Co.

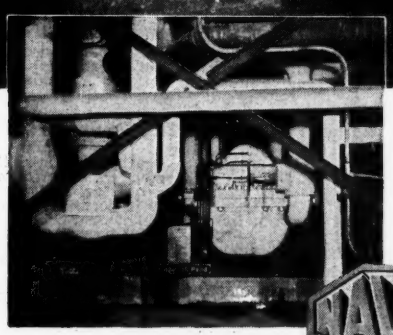
210A **Flanges for Severe Service**—This 4-pp bulletin describes and illustrates a flange specially developed for services involving severe abrasion and corrosives, and for use in suction and discharge service. Photos and sketches illustrate the flange and its parts. Bulletin also covers a flexible rubber pipe for use with abrasive or corrosive material, as well as an acid- and corrosion-resistant duct, listing solutions this duct will handle. Goodall Rubber Co.

HEATERS, HEATING

211 **Space Heaters**—Bulletin 523, 12 pp, covers forced air space heaters, direct-fired by oil, gas or combination fuel and ranging in output from 400,000 to 2,000,0000 Btu. for comfort heating, year-round ventilating, tempering make-up air, process drying and heat curing. It discusses their design and principle of heat distribution and lists 18 reasons why these heaters are recommended for open space heating. Includes specifications, capacity and dimension tables, sketches illustrating operating principles and construction details and photographs showing the heaters in use. Dravo Corp.

212 **Fan Heater Bulletin**—Here's a 2-pp illustrated bulletin (No. 109) on a new high pressure steam fan heater de-





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The measure of any piping system, after the proper design has been reached, is the "fit." The knowledge which we have gained in the past 40 years is your guarantee of an accurate and workmanlike piping system. Navco quality in workmanship and design is evidenced by the many successfully operating installations which we have made for every industry. Consult Navco for your next piping job.

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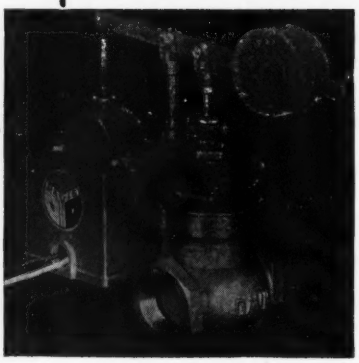
SOLENOID VALVES

Built for Heavy Duty Industrial Service



DAVIS industrial-type Solenoid Valves are not to be confused with ordinary, low cost, commercial types. Davis products are engineered to handle the "tough jobs" on a basis of SATISFACTION GUARANTEED. The Davis line is complete—standard and special designs are available for every conceivable kind of automatic control application.

Our Engineering Department is always ready to assist in solving any problems regarding the use of Solenoid Valves. When submitting your problem, give complete information so that the proper valve may be selected for the service. Bulletin No. S-1 on request.

No. 93 ***(Illustrated above)*** **is a self-contained, pilot operated, single seated, tight closing valve, built with full port opening to insure maximum flow with minimum pressure drop. Action is visible—may be operated by hand if current fails. Renewable valve disc. Sizes ½" to 4". Suitable for control service on steam, air, gas, water or oil lines.**

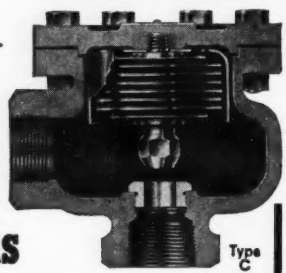
DAVIS REGULATOR COMPANY

2508 S. Washtenaw Ave., Chicago 8, Ill.

WHY →

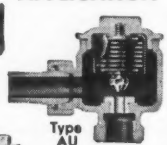
Nicholson Steam Traps Are Being Adopted in

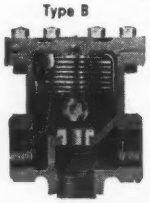
Advanced PLANT ENGINEERING Programs

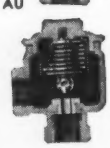


The repeated adoption of Nicholson steam traps in plants with big "cost-reduction-through-modernization" programs is a noteworthy indication of their advanced features. For instance, where manufacturing is put on a continuous basis Nicholson traps help maintain essential operating conditions because they: 1) operate on lowest temperature differential for faster action; 2) eliminate adjusting valves for varying pressures; 3) prevent air-binding; 4) furnish 2 to 6 times average drainage capacity. Size ¼" to 2"; pressure to 225 lbs.

5 TYPES FOR EVERY PLANT APPLICATION







Catalog 488 or see Sweet's

W. H. NICHOLSON & CO.

160 Oregon St., Wilkes-Barre, Pa.

signed for complete utilization of both sensible and latent heat of high pressure steam. One page is devoted to description and photos of the heater. Other page contains a sketch in color showing how the heater works. Niagara Blower Co.

213 **Heating Element Data**—Bulletin No. 20, 8 pp, contains detailed capacity and dimension tables on manufacturer's "Paracoil" heating elements. Illustrations and descriptions provide instruction for installation of heating elements and diagrams show six commonly used installation arrangements of hot water generation using these heating elements and storage tanks. Includes conversion table for steam and temperature conditions for determining capacity of any size heating element. Davis Engineering Corp.

214 **Steam Humidifiers**—Bulletin 1771 describes the company's steam humidifiers for automatically controlling relative humidity for the prevention of dry air damage to hygroscopic materials such as paper, leather, wood, cork, foodstuffs and other materials in storage or in process. The bulletin also describes the effect of relative humidity on human comfort and health and explains how maintenance of proper humidity will eliminate the fire and explosion hazards of static electricity where inflammable dust, vapors or liquids are present. Tables and charts are included on desirable relative humidity in various industries. Two useful sections of the bulletin are "How to Select," and "How to Install," both of which are accompanied by excellent line drawings presented in two colors. Armstrong Machine Works.

214A **Packaged Heat**—Unit heaters featuring low first cost, easy installation and continued low cost per Btu are presented in this 12-pp booklet. Text explains how these packaged heaters are designed to operate instantly on oil or gas, fit heat output to requirements of day, and provide heat where it's wanted. Illustrations include photos of heaters and several installations and many sketches showing advantages and construction details. Prat-Daniel Corp.

215 **Tubular Heat Exchangers**—Bulletin 916 is a particularly informative 32 page bulletin which has "just been issued." The bulletin describes the present designs of the company's tubular heaters, coolers, condensers and heat exchangers and their distinctive features. The various types of shells, tube bundles, stationary heads and floating heads are fully explained, together with statements of the particular services for which each is suitable. An additional helpful feature of the bulletin are tables of the characteristics of tubing, the thermal resistance of tubes and pipes of many different metals and alloys, and the specific gravity and pounds per gallon corresponding to degrees Baume and degrees API. Also presented is a chart of the specific heats of midcontinent crude oils and the charts for solving the MTD formula with correction factors for other than countercurrent conditions. The Griscom-Russel Co.

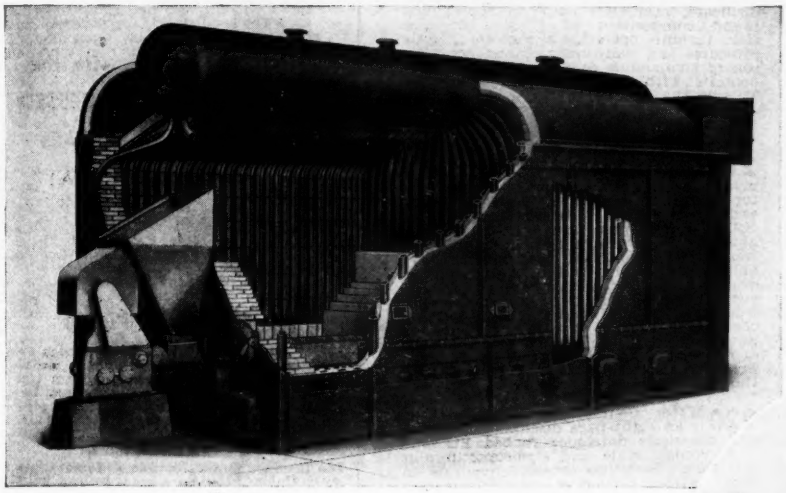
215A **Chemical Soot Removal**—Ten-pp Bulletin 43, on the chemical removal of soot from boiler furnaces, explains the research work that led to the development of manufacturer's new chemical soot remover and slag alleviator for coal fired boiler furnaces. It tells how this combustion catalyst prevents soot formation on furnace internals and helps to end the smoke problem. National Aluminate Corp.

TREATMENTS, PREVENTIVES

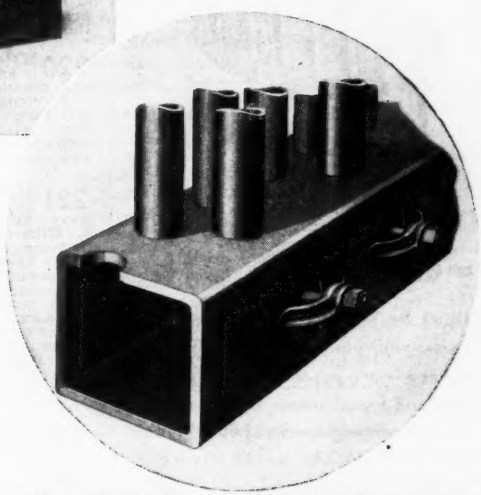
216 **Protective Coating**—Bulletin 1540, 4 pp, is devoted to a corrosion resistant coating for cold, wet surfaces. Tells its protection against corrosive effects of natural fresh and salt water, cold acid and alkali solutions, acid fumes and atmosphere under shelter. Discusses in detail the use of this coating in water storage tanks and in condensers. Tells how coating should be applied and how to order it. Bulletin also includes photos and description of equipment recommended for use in applying the coating. The Dampney Co. of America.

217 **Corrosion Analysis**—Excellent working data on galvanic corrosion is contained in this 8-pp technical study of corrosion by concentration cells, reprinted from Inco Corrosion Reporter, Vol. 3, No. 1. Discusses concentration cells, the metal-ion cell type, oxygen cell type, reversible concentration cells, their practical aspects and some rules for minimizing or preventing concentration cell corrosion. Illustrated with sketches showing conditions which accelerate corrosion. The International Nickel Co., Inc.

TYPE-VL *A Low Headroom*
2-DRUM WATER WALL BOILER



SHIPPED BUILT-UP IN SIZES TO 300 H. P.



Water Wall tube arrangement—1 Downcomer for each 2 Riser Tubes

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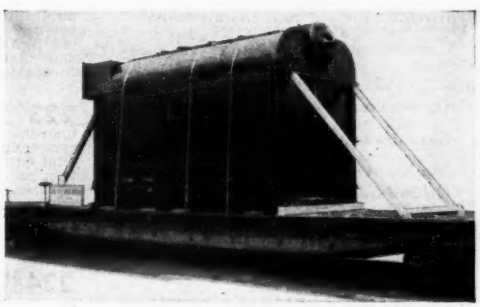
BACKED by a long experience gained in the manufacture of over 500,000 H.P. of Erie City 2-drum water tube boilers and of thousands of complete built-up boiler units, Erie City has incorporated side wall water cooling as an integral part of a low headroom 2-drum boiler. Outstanding of many features, is the method of obtaining a ring flow circulation, in each side wall element. A downcomer tube is provided for each pair of radiant (riser) tubes in the side wall, which, with two front wall downcomers assure an ample supply of clean circulating water in the water walls at all times. Insulation between riser and downcomer tubes keeps water at lower temperature in the downcomers while heat is rapidly removed from refractory through risers. Write for VL bulletin that clearly describes and illustrates this and many other features.



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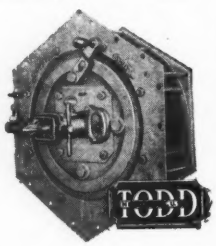

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218 Turbine Blade Deposit Study—Identification and prevention of steam turbine blade deposits and boiler water conditioning to prevent such deposits are discussed in the new 16-pp illustrated Bulletin 28B7030. Describes x-ray diffraction methods employed by the company for identification purposes and the results obtained. Tables list the partial chemical analyses of deposits containing sodium disilicate, occurence data on compounds found, composition of turbine deposits from turbines operating at various throttle pressures and temperatures, and comparison of compounds found in turbine blade deposits with boiler operating pressures. This is the 10th in manufacturer's series of engineering bulletins. Allis-Chalmers Mfg. Co.

219 Boiler Water Manual—Factual information on standard methods of applying chemicals in the treatment of water for boilers is presented in this 16-page technical bulletin, called Standard Method 122. Discusses pretreatment of raw water, application of chemical feeding to pretreating operations and both constant rate and flow responsive feeding direct to boiler drum and to feedwater systems. Also discusses condensate returns, flushing periods, condenser cooling water treatment and chemical tanks. Illustrations include photographs of two feeders and diagrams of the various methods described. Punched for filing in ring binder. Proportioneers, Inc.

220 Water Conditioning Bulletin—This is an eight-page discussion of water and chemicals developed for conditioning it to control scale and algae and inhibit corrosion. Describes several chemicals in detail, giving properties, composition and application. Also discusses special purpose chemicals. Wright Chemical Corp.

221 Antifoaming Compound—This new technical bulletin covers the company's latest product known as Antifoam 8. With the accelerated rate of operation in many power plants today, foaming from either chemical or mechanical origin has become one of the prime problems in boiler operations. This technical bulletin presents reasons for foaming and deals with the chemical causes, especially the application of antifoams to elimination of carryover from these causes. After discussing the causes for foaming the bulletin goes on to describe the proper dosage and feeding and results obtained from the use of Antifoam 8. E. F. Drew & Co., Inc.

222 Corrosion Resistance of Nickel Alloys—Technical Bulletin T-3 contains 44-pp of illustrated information on the resistance of high nickel alloys to corrosion by sulfuric acid. Although technical in nature, it is written so as to be readily understood by non-technical staffs. Performance of 30 nickel-bearing materials in a wide range of service is discussed, and there are 86 tables and 33 graphs and photos in addition to text. Problems involving a wide range of operations from the pickling of steel to petroleum refining and textile processing are covered. The International Nickel Co., Inc.

223 Cleaning Industrial Equipment—This is a general information bulletin on manufacturer's service for cleaning steam generating, heat exchange and other industrial equipment. Also included is information on pipe line cleaning and water well acidizing. Illustrations of these services are included, and bulletin treats in detail the methods used to remove incrustations from internal surfaces economically with minimum of downtime. Dowell Inc.

224 Anti-Foam Treatment — This 4-pp bulletin covers a new formula in powder form to be applied along with anti-scale treatment for improving steam quality, controlling scale in boiler feed system and sludge conditioning. It discusses the problem of steam contamination and explains the action of this polyamide anti-foam treatment. Tells how it should be applied and gives dosage requirements. A discussion of its advantages is accompanied by photos showing the effect of polyamide action on a boiling dilute Nacconol solution. Dearborn Chemical Co.

225 Boiler Corrosion—A 12 page article discussing the cause and prevention of corrosion in boiler systems is presented in Betz Technical Paper No. 111 titled "Corrosion: Its effect in Boiler Systems." The corrosive effects of oxygen, carbon dioxide, ammonia, hydrogen sulfide, acidity and physical factors are evaluated. Numerous illustrations, graphs and tables aid in understanding the article. W. H. & L. D. Betz.

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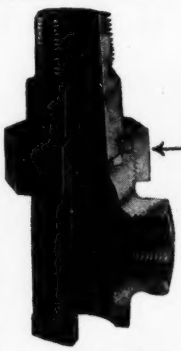

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226 **Application Data Bulletin** — Titled "The Aroclors," chlorinated biphenyl and chlorinated poly-phenyls, this booklet describes the unique properties which enables this material to fulfill certain requirements. The Aroclors have won a place in the electrical insulating field and in such widely differing applications as non-flammable hydraulic media, high-temperature and high-pressure lubricants, heat-transfer and expansion media, sealing compounds, adhesives and protective coatings, including plastics, pigments, lacquers, paints and varnishes. This booklet contains 28 pages and presents the combined information gathered by the company from what it believes to be reliable and dependable sources. Monsanto Chemical Co.

ELECTRICAL

227 **Electrical Diagram Guide**—The purpose and use of electrical diagrams supplied with switchgear equipment are explained in Bulletin GET 1293A. It was written to help those who install, operate or maintain switchgear equipment make the best use of the diagrams that come with such equipment. Discusses in detail one-line, elementary, connection and interconnection diagrams. It tells their scope and uses and illustrates symbols used and common variations and explains ASA device function numbers and conventions. General Electric Co.

228 **Transformer Buyers Guide**—An excellent technical manual on instrument transformers is this 80-page catalog, GEA-4626B. Contains descriptions, photographs and index of ratings and construction for indoor and outdoor potential transformers, indoor and outdoor current transformers, outdoor metering outfits and portable potential and current transformers, according to cycles. Dimensions, prices and shipping weights are included with listing of each type, as is reference to manufacturer's bulletin dealing with that type of transformer. Index of types shows voltage and frequencies. Also included are tables showing mechanical and thermal limits of current transformers. Book has firm covers and ring binding for long-time reference use. General Electric Co.

229 **Induction Motor Bulletin**—A four-page illustrated folder, PB 7000-1, describes manufacturer's new two-pole, 200 to 3500 hp induction motor of fabricated steel construction, available in enclosed or separately ventilated types. Construction features are discussed in detail and illustrated with photographs. Elliott Co.

230 **Synchronous Generators**—This Bulletin, 05B6139A, describes construction features and electrical characteristics of engine-type synchronous generators in standard ratings from 25 to 10,000 kva and for standard speeds from 100 to 600 rpm, for Diesel, steam or gas engines. Also describes and illustrates mechanical construction of stators and rotors and discusses machine characteristics, ratings, voltages, frequencies, phases, temperature rises and operation at high elevation. Illustrations show typical installations. Available control accessories are listed, as are manufacturer's other products and territorial sales offices. Allis-Chalmers Manufacturing Co.

231 **Induction Motors**—Twelve-pp Bulletin GEA 3580D covers induction motors, the open, dripproof type, 1 to 2000 hp. Cites performance records of several of these motors, and explains and illustrates construction features. Stresses the easy installation and maintenance and smooth operation of the motors. Contains photos of several of them in use. Apparatus Dept., General Electric Co.

PUMPS, COMPRESSORS, ENGINES

232 **Condensers**—Bulletin 441-C, 28-pp, covers in detail every phase of manufacturer's line of condensers—their simplicity of design, accessibility, construction features. Illustrated with photos and drawings showing complete assemblies, parts, principles of operation. Bulletin also discusses emergency replacements, service and maintenance facilities available, and auxiliary equipment. Includes condenser tube data, pressure-conversion tables. Condenser Service & Engineering Co.

233 **Chemical and High Pressure Pumps**—Catalog 146, 30 pp, covers controlled volume pumps for chemical and high pressure service. Discusses their general applications, tells how they work, and explains manual stroke adjustment and automatic control. Contains photos and descriptions of these pumps in a wide range of capacities. Technical data includes capacity pressure selection tables, a three-color table showing materials of construc-

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234 **Compressor Selection Chart**—Here's a new selection chart, based on normal applications handling air with atmospheric intake pressure. It simplifies selection of proper size compressor for average industrial use, with quick comparison between discharge pressure pounds per square inch gage and piston displacement cubic feet per minute and shows recommended compressor bore and stroke in inches. Chart covers two letter-size pages. Worthington Pump and Machinery Corp.

235 **Air Compressor Lubrication Manual**—Valuable information on air compressor maintenance is contained in this 40-page book on the lubrication of air compressors, second edition. Subjects treated include compressed air, compressors and related equipment, lubricating systems, compressor oils and their applications, lubrication requirements operating hints, oil requirements, storage and care of compressor oils, and safety precautions. All discussions are illustrated with large, clear photographs and drawings showing construction and operation of compressors, their lubricating systems, etc. Cities Service Oil Co. (In the South, Arkansas Fuel Oil Co.)

235A **Steam Pumps**—This is manufacturer's collection of bulletins covering all types of centrifugal and reciprocating pumps for a wide range of industrial uses. Contains more than 80 pp in all and includes photos, dimensions, specifications, ratings and application data. Warren Steam Pump Co.

236 **Steam Engine Governor Data**—This new bulletin No. 502, describes the company's Type EN fully enclosed self-lubricated governor which is described as giving "precise, dependable engine speed control." Illustrations of the unit are presented and a parts list, accompanied by a sectional diagram is given. One section "Installation and Care" tells how to assemble governor to engine cylinder and how pulleys should be proportioned, the proper type of belt for use with the governor, correct lubrication procedure, method of packing and other data. Troy Engine & Machine Co.

237 **Turbine Catalog Collection**—This is a valuable collection of bulletins in loose-leaf form. They cover a complete description of manufacturer's solid wheel turbines and feature cross section drawings of typical units for both moderate and high steam pressure conditions. Also provides a description of an axial flow impulse, both single and multi-stage, and complete data on speed increasing and speed reduction gears. The Terry Steam Turbine Co.

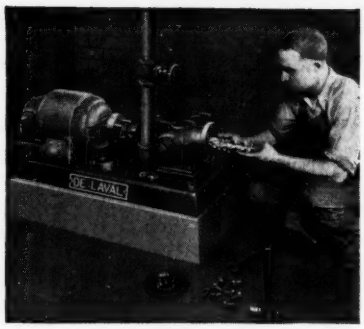
237A **Velocity Stage Turbines**—Catalog 82-19R, 8 pp, features turbines for mechanical drives designed to operate under all inlet steam conditions up to 600 psig and 750 F. Gives complete specifications, dimensions and includes chart showing how to estimate turbine sizes. Illustrations include cutaway view, photos of parts. Speed governor and regulating valve, and emergency governor and trip valve are described in detail. De Laval Steam Turbine Co.

INSTRUMENTS AND CONTROLS

238 **Combustion Instrument Catalog** — Twelve-pp Condensed Catalog 49-687 describes briefly and illustrates instruments and controllers for both boiler rooms and industrial processes. Equipment covered includes automatic controllers, meters for indicating content of flue gases, draft gages, flow meters, gas analyzers and recorders, and combustion testing equipment. The Hays Corp.

239 **Water Gages** — Eight-page Bulletin E-1 covers line of water gages for stationary and locomotive boilers, marine and refinery service and tanks for all pressures and temperatures. Listings include photos of all gages, sizes and construction details. Bulletin S-2, four pages, covers gage glasses, glass guards, sight flow indicators and related equipment. Ernst Water Column & Gage Co.

240 **Temperature Measuring Instruments** —For all those responsible for the safe operation of electric power equipment, this company has just issued a revised 34 page catalog ND4-33-461 describing the company's instruments for meas-



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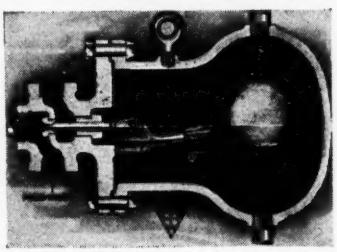

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241 **Smoke Density Recorder** — Bulletin 211, 4 pp, tells how company's bolometer-type smoke density recorder promotes efficient furnace operation and how it helps in the battle against smoke nuisance. It describes and illustrates the smoke detector which consists of a bolometer receiving and measuring radiation from a sealed beam light source. Recorder specifications, installation requirements, and measuring circuit details are also discussed. Bailey Meter Co.

242 **Boiler Water Level Control** — Bulletin 487 describes completely the installation of boiler water level control equipment at the Blackhawk Generating Station, Wisconsin Power & Light Company. Photographs of the installation are presented as is a schematic layout of the entire station along with tabulated significant data. A large, full-page cross section of the B & W Type FH integral furnace boiler is presented and other drawings and photographs show the accompanying equipment. Northern Equipment Company.

243 **Multiple Signal and Alarm Systems** —Panalarms, multiple signal and alarm systems adaptable to all types of industrial and power plant applications, are described in 12-page, letter-size, illustrated Series 300 Panalarm bulletin. Gives details of operation, shows types for panel and well mounting, wiring circuits, operation sequence, dimensions of units. Shows how Panalarms indicate by light and horn signals, acknowledging button, for normal and abnormal conditions. Systems are supplied in multiple units up to 12 in single cabinet; extra space for spare units; provisions for future additions; simple field wiring. Price list included. Panalarm Products, Inc.

244 **Instrument Handbook**—"Modern pH and Chlorine Control" is a 100-pp catalog containing a great deal of valuable information in addition to covering manufacturer's line of scientific instruments and accessories. It explains the meaning of pH control, the electrometric and colorimetric methods of determining pH, and gives values of common acids, bases and foods, as well as maximum capacities of buffer systems. It also discusses in detail the applications of pH and chlorine control in air conditioning, water treatment, boiler water and many other industrial applications, recommending instruments and solutions. Instruments are illustrated by photograph, their functions described and sizes and prices given. W. A. Taylor & Co.

DUST COLLECTING

245 **Dust Collectors** — Dust collecting equipment for power plants, foundries, cement plants and similar industries is the subject of Bulletin No. 1428, 26 pp. Contains many photographs of installations, also photos showing equipment being tested in company laboratories. Discusses services offered by manufacturer in analyzing individual installation requirements and recommending equipment for the job. American Blower Corp.

246 **Filter Catalog**—Manufacturer's line of filters for air and other gases, liquids, chemicals and special applications is presented in 44-pp Form 450. Its pictorial index is followed by a brief discussion of the applications of pipeline filters, air intake filters, liquid filters and ventilation and air conditioning filters. Each type illustrated and described in detail. Capacities, specifications, sizes given. Includes layout drawings, a listing of some of the filtering media available, installation data on panel filters, and selection chart for dry type filters. Dollinger Corp.

MATERIALS HANDLING

247 **Continuous Weighing of Dry Materials**—Bulletin E4-550 describes the company's new meter for continuously weighing and totalizing the flow of dry materials on conveyor belts. The meter can also be used for the automatic proportioning and controlling of dry or liquid feeders for secondary ingredients. The bulletin describes how the device operates, how it is constructed and gives various features. A double page spread, printed in two colors, presents a typical installation of the unit on a belt conveyor. Blueprint

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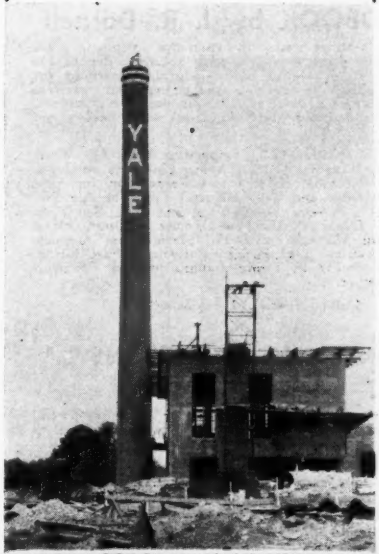

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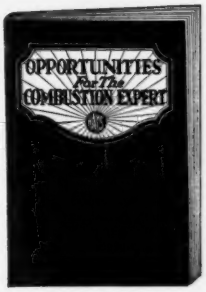

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250 Industrial Insulation Catalog—Mineral insulations for practically every purpose are covered in this 20-pp illustrated catalog. It describes in detail insulating cements for both high and low temperatures, high temperature block insulation, block finishes, felts, blanket insulation, pipe coverings, loose wool, weatherproofing and stack paints. Includes information and what each class of insulation is for, what it can be expected to do, how it's applied, how it's packaged and, in most cases, how much it costs. Discusses requirements of a good insulation and tells how these products meet the requirements. Forty-Eight Insulations, Inc.

251 Cooling Towers—Double-flow cooling towers are featured in 20-pp Bulletin DF. It discusses the principle of double-flow cooling, the mechanical equipment utilized, construction features of a tower of this type, water distribution, coil shed, and safety factors. Recommends sizes for different applications and includes photos of many installations. The Marley Co., Inc.

252 Concrete Floors Q & A — A new booklet titled Lumnite Concrete Floors—Corrosion Resistant and Heat Resistant, has just been published. The detailed information contained in this booklet brings up to date, the service experiences and late developments in this field. The information covers methods and materials used in placing corrosion resistant concrete in a wide variety of industrial applications. Typical uses of corrosion resistant concrete are listed for many industries and also given, are the answers to a number of questions often asked about it. A section on placing and finishing corrosion resistant floors will be helpful to prospective users. Lumnite Division, Universal Atlas Cement Company.

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253 Coal Crushing, Sizing — Bulletin 3007 describes the company's Bradford breaker a coal crusher, sizer and scavenger. The bulletin presents drawings of the breaker, tells how it works and then presents the complete story of its operation at the coal mine and coal cleaning plant at the By-Product Coke Plant and at the Power Station. The back section of the catalog presents engineering information on capacities, dimensions and dimensioned line drawings. Pennsylvania Crusher Company.

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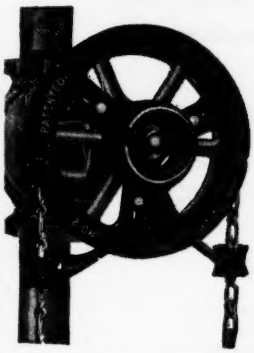

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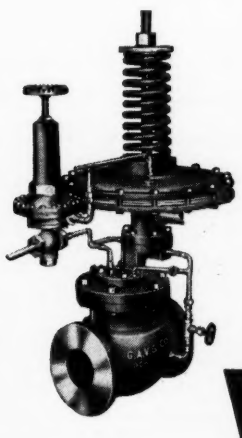

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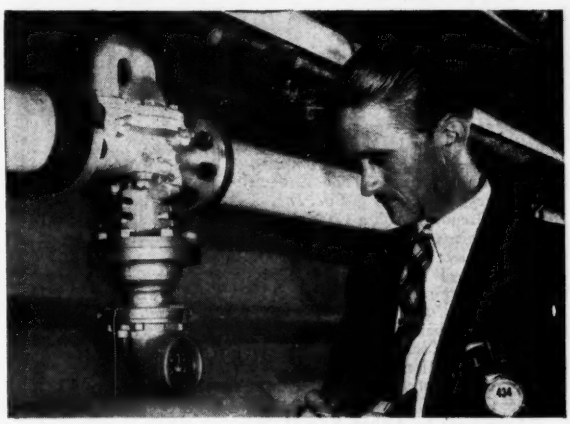

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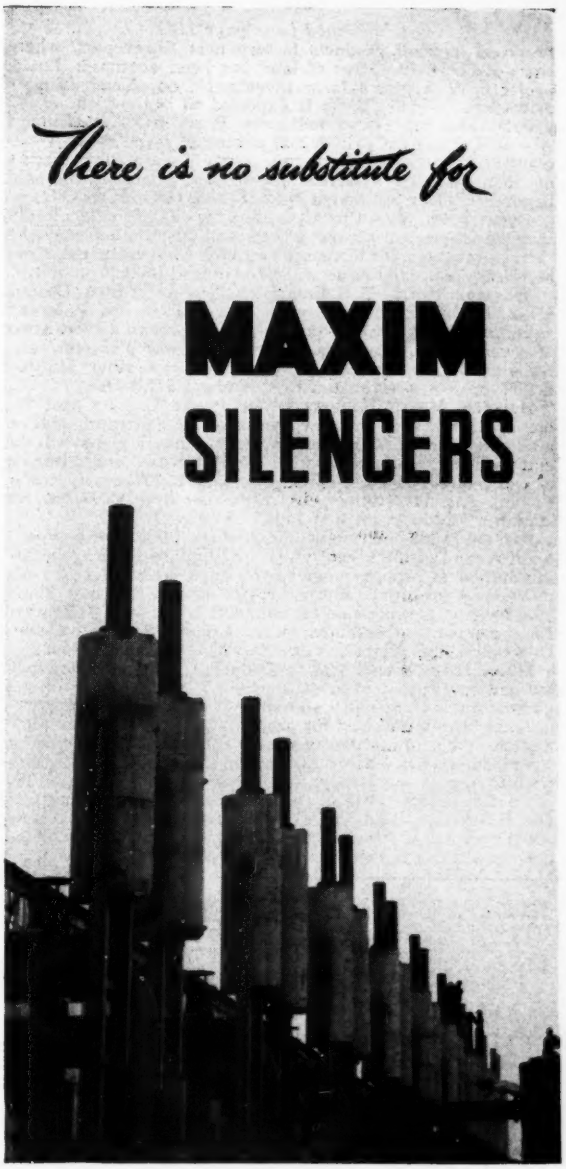

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(Continued from page 110)

proposed new oil products factory near Shreveport, where tract of about 600 acres of land has been acquired. Entire project will represent large investment; no official estimate of cost announced. Work is expected to begin soon.

Baltimore, Md.—Lord Baltimore Press, Inc., Greenmount Ave. and Oliver St., printer and publisher, plans steam power plant at new one-story printing plant, totaling about 4 acres of floor space on 33-acre tract of land. Construction will begin soon. Cost estimated about $1,250,000, with machinery.

Hagerstown, Md.—City Council plans expansion in municipal steam-electric power plant, with installation of additional equipment for increased capacity. Cost estimated about $1,500,000, and bond issue will be arranged in that amount.

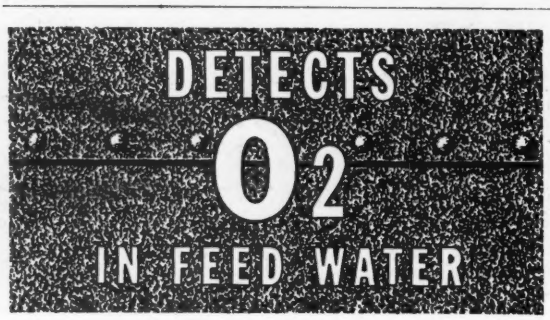
Brockton, Mass.—U. S. Engineer Office, Army Base, Boston, Mass., has plans under way for new hospital for Veterans' Administration, Washington, D. C., at Brockton, consisting of several multi-story buildings, with power plant for central-heating service, refrigerating plant and other utilities. Entire project is estimated to cost about $17,000,000.

Holyoke, Mass.—Holyoke Water Power Co., 1 Canal St., has approved plans for new hydroelectric generating station and will proceed with work at once. Initial plant will be equipped for an initial rating of 15,000-kw, and ultimate capacity of 60,000-kw, divided into four 15,000-kw hydraulic turbine-generator units. Cost estimated over $5,000,000 for station structures and first unit.

Detroit, Mich.—Wrought Magnesium Corp., 2457 Woodward Ave., Detroit, recently organized, plans steam-generating station at proposed new plant on 10-acre tract of land, now being acquired. Entire project reported to cost about $500,000, and is scheduled for completion in about 12 months. New company is affiliated with Brooks & Perkins, Inc., Donovan Bldg., Detroit, fabricated magnesium products.

Elbow Lake, Minn.—Village Council has plans under way for new municipal power station, using Diesel engine-driven generators and accessory equipment. A bond issue of $280,000, has been authorized for project.. Hitchcook & Estabrook, Sexton Bldg., Minneapolis, Minn., are consulting engineers.

Columbia, Miss.—South Mississippi Electric Power Association, Columbia, plans new steam-electric generating station for power service to group of 11 electric cooperative organizations in that area. It will be equipped for large capacity and is estimated to cost about $8,000,000. Financing will be arranged through Federal Aid.



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In addition to instruments used in power plant operation, *Cambridge* also makes pH Meters and Recorders, Galvanometers, Gas Analyzers, Fluxmeters, Exhaust Gas Testers, Surface Pyrometers and other instruments used in Science, Industry and Medicine. *Write for literature, stating application.*

CAMBRIDGE INSTRUMENT CO., INC.
3767 Grand Central Terminal, New York 17, N. Y.
Pioneer Manufacturers of
PRECISION INSTRUMENTS

Newark, N. J.—Anheuser-Busch, Inc., 721 Pestalozzi St., St. Louis, Mo., plans a new power house at proposed new brewery on 50-acre tract of land at Newark. Project will comprise several large units, with rated capacity of about 1,250,000 bbl per annum. It is planned to begin work soon and have plant ready for service in about 12 months. Cost estimated close to $20,000,000.

Goldsboro, N. C.—Carolina Power & Light Co., Raleigh, N. C., plans new steam-electric generating station near Goldsboro, with initial capacity of 75,000-kw. Proposed to begin work early in 1950. This is part of an expansion and improvement program arranged by company for 36 months period beginning next year and concluding in 1952, to cost approximately $35,000,000. Of this amount, about $28,000,000 will be expended for additional generating capacity.

Lexington, N. C.—Frank Ix & Sons, Inc., 3300 Hudson Blvd., Union City, N. J., rayons, broadsilks, etc., plans steam-generating station at proposed new textile mill near Lexington, where tract of about 113 acres of land has been acquired. Entire project will cost close to $1,000,000. Proposed to begin work soon.

Cleveland, Ohio—Cleveland Electric Illuminating Co., Illuminating Bldg., plans expansion in generating facilities and will have plans prepared soon for new steam-electric unit, to be located on site near Cleveland, lately acquired, or forming an extension to one of present power plants, either at Avon, Cleveland or Ashtabula, Ohio, still to be determined. Estimates of cost are being made.

Pittsburgh, Pa.—U. S. Engineers Office, New Federal Bldg., Pittsburgh, has plans in progress for new hospital for Veterans' Administration on local site, consisting of a large group of one and multi-story buildings, with steam-generating station for central-heating service, refrigerating plant and other utilities. Cost reported over $12,000,000. Bids are expected to be asked in November.

West Pittsburgh, Pa.—Pennsylvania Power Co., New Castle, Pa., has begun foundations for proposed addition to steam-electric generating plant at West Pittsburgh. Installation will include a new turbine-generator, high-pressure boilers and auxiliary. Cost reported approximately $11,500,000, including extensions in transmission lines, power substations and other operating facilities.

Ponce, Puerto Rico—Puerto Rico Oil Refining Co., Ponce, recently organized, care of Parsons, Brinckerhoff, Hall & MacDonald, 51 Broadway, New York, N. Y., consulting engineers, plans power plant at proposed new oil refinery in Puerto Rico, to be equipped to handle about 25,000-bbl of crude oil daily. Cost reported close to $20,000,000. Work will begin in near future, with completion scheduled late in 1950. Engineers noted are preparing plans and will be in charge of project.

Galilee, R. I.—Dehydrating Process Co., Inc., 10 High St., Boston, Mass., dehydrated food products, plans boiler plant at proposed new fish-dehydrating plant at Galilee. Negotiations are now in progress for site. Entire project is estimated to cost close to $250,000.

Fayetteville, Tenn.—Elk Cotton Mills, cotton yarns, will increase power plant facilities at mill in connection with new addition for large capacity. Entire project will cost about $750,000, of which approximately $550,000, will be used for equipment requirements. McPherson Co., 403 South Main St., Greenville, S. C., is engineer.

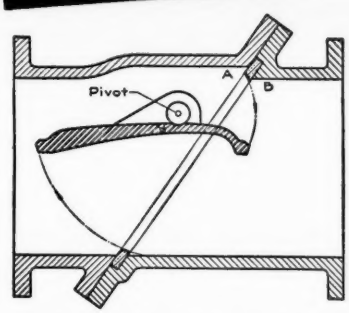
Beaumont, Texas—Gulf States Utilities Co., 302 Liberty Ave., has plans maturing for expansion in local generating station, with installation of new 60,000-kw turbine-generator, high-pressure boiler and auxiliary equipment. Cost reported about $3,000,000. Stone & Webster Engineering Corp., 49 Federal St., Boston, Mass., and Mellie Esperson Bldg., Houston, Tex., is consulting engineer.

Houston, Texas—A. O. Smith Corp., 3533 North 27th St., Milwaukee, Wis., steel products, automobile parts, etc., plans steam power plant at proposed new mill at Houston for production of large diameter welded steel pipe for oil and gas service. It will comprise several units and will be constructed jointly with Sheffield Steel Corp., Shepherd Ave., Kansas City, Mo. Entire project reported to cost about $5,000,000.

Longview, Texas—Southwestern Gas & Electric Co., Shreveport, La., plans addition to Knox Lee electric generating station near Longview, with installation of equipment for increased capacity. Cost reported about $3,500,000.

Tacoma, Wash.—Stauffer Chemical Co., Inc., 636 California St., San Francisco, Calif., industrial and other chemicals, fertilizer products, etc., plans steam-generating station at new superphosphate plant at Tacoma, where site has been selected. Project will comprise several units and will represent large investment; no official estimate of cost announced. Work will begin soon.

THERE IS *No Slamming* WITH CHAPMAN TILTING DISC CHECK VALVES



Cross-section of the Chapman Tilting Disc Check Valve illustrating the way that the balanced disc is supported on the pivot, with arrows showing the travel of the disc. A feature of the design is that the disc seat lifts away from the body seat when opening, and drops into contact when closing, with no sliding or wearing of the seats.

BECAUSE of the design of the balanced hinge-pinned disc, Chapman Tilting Disc Check Valves always close smoothly and quietly. There is no slamming, no hammering, no destructive pipe-line stress.

When open, the disc rides smoothly in the flow. As it closes, the effect of the stream on the short flap cushions the contact with the body seat. There is no sliding action and therefore wear on seats is reduced to a minimum. In addition, head losses are lowered as much as 65% to 80% over those experienced with conventional type check valves.

Available in either iron or steel.

The Chapman Valve Mfg. Co.
INDIAN ORCHARD, MASS.

$6,000 SAVED ON CHEMICALS ALONE!

WITH THE PERMUTIT SLUDGE BLANKET HOT PROCESS

A Permutit® Sludge Blanket Hot Process Water Softener was installed recently in a leading paper mill. The results of several years' operation speak for themselves. The plant's estimated annual savings on treating chemicals exceeded $6000. *Silica in the boiler feed makeup was reduced to ⅕ the amount previously obtained with a conventional water softener.* By feeding more magnesia, silica content could have been reduced to less than 1 ppm.

And here are some extra benefits from the Permutit Hot Process: More efficient use of magnesia! Longer filter runs! Lower turbidity in settling tank effluents! Greater adaptability to flow rate fluctuations! Easier operation! This is another achievement exemplifying Permutit leadership in water conditioning!

Characteristics	CONVENTIONAL DESIGN	SLUDGE BLANKET DESIGN
Silica in raw water, as SiO_2 ppm	55	55
Silica in effluent, as SiO_2 ppm	11	2.0
MgO feed, ppm	76	59
Parts SiO_2 removed per part MgO	0.6	1.1
Average retention time of $Mg(OH)_2$ in hours	4.7	100
Contact time of water with $Mg(OH)_2$ in minutes	92	87
Hardness of effluent, as $CaCO_3$ ppm	21	15
Average load on softener, % rated capacity	65	46
Temperature in softener	220°F	243°F

Write for full information to the Permutit Company, Dept. PG-11, 330 West 42nd Street, New York, 18, N. Y., or to the Permutit Company of Canada, Ltd., Montreal.

PERMUTIT PRODUCTS for Power Plants

Sludge Blanket Hot Lime Soda Softener (including silica removal) • Zeo-Karb: Hydrogen and Sodium • Demineralization combined with Silica Removal • Silica Removal by Hot or Cold Precipitation Processes • Supplementary Chemical Feeding Equipment • Ranarex Mechanical CO_2 Indicators and Recorders • Continuous Blowoff Equipment • Deaerators and Open Heaters

PERMUTIT

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